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BEFORE THE

SUBCOMMITTEE ON
SCIENCE, TECHNOLOGY, AND SPACE

OF THE

COMMITTEE ON COMMERCE,
SCIENCE, AND TRANSPORTATION
UNITED STATES SENATE

NINETY-NINTH CONGRESS

SECOND SESSION

ON

FISCAL YEAR 1987 NASA AUTHORIZATIONS

MARCH 20, APRIL 10, 16, 23, MAY 8, AND AUGUST 5, 1986

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NASA AUTHORIZATION

THURSDAY, MARCH 20, 1986

U.S. Senate,
Committee on Commerce, Science, and Transportation,
Subcommittee on Science, Technology, and Space,
Washington, DC.

The subcommittee met, pursuant to notice, at 9:30 a.m., in room SR-253, Russell Senate Office Building, Hon. Slade Gorton (chairman of the subcommittee) presiding.

Staff members assigned to these hearings: Pete Perkins, professional staff member; Marty Kress and Steve Palmer, minority professional staff members.

OPENING STATEMENT BY SENATOR GORTON

Senator Gorton. Welcome to this first in a series of hearings of the Subcommittee on Science, Technology, and Space on the subject of NASA's fiscal year 1987 authorization.

Today we will examine the activities and budgets of NASA's Aeronautical Research and Technology Programs. We will examine at the same time the administration's National Aerospace Plane Program.

The always difficult task of making programmatic and budgetary decisions in relation to NASA's operations is complicated this year by the impact of the shuttle *Challenger* accident and by the overriding concern of achieving the budget deficit goals which Congress has established.

Even though no budget resolution has as yet been approved by the Congress as a whole, or even by the Senate, some of our preliminary work indicates that apart from any additional funding that may be provided for orbiter replacement activities, NASA's fiscal year 1987 funding is likely to be less than the administration's budget request of $7.7 billion.

That was reflected in the budget resolution adopted by the Senate Budget Committee yesterday. Consequently, Congress and NASA have to examine even more carefully our Nation's priorities in aeronautical research and technology. That review will prove all the more critical in light of the growing international competition to our once unchallenged superiority in aeronautical technology and sales. We should be encouraged, however, that the administration has decided formally to initiate the National Aerospace Plane Program, an endeavor which could profoundly affect the efficiency with which we transport passengers from one continent to another, and with which we deliver payloads to space. In addition, one cannot overlook the potential that this program holds for our national security.

It is becoming increasingly clear that developing an operational vehicle which could meet the goals of the National Aerospace Plane Program will require the resolution of a number of difficult technological issues. In addition to this, we will likely continue to face annual budget deficit goals which will limit to some degree our resources for that kind of program.

Nevertheless, I look forward to the successful completion of this initiative, just as I anticipate the continued success of NASA's Aeronautical Research and Technology Program in contributing to the American preeminence in the global arena of aeronautical technology and sales.

With these thoughts in mind, we are pleased to have with us a number of distinguished Government witnesses and industry witnesses who will share their thoughts on these issues with us. We are delighted, of course, to start with Dr. Colladay, and we are ready to hear whatever it is that you wish to share with us, Doctor.

STATEMENT OF RAYMOND COLLADAY, ASSOCIATE ADMINISTRATOR FOR OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY, NASA, ACCOMPANIED BY EDMUND SANCHEZ, DEPUTY DIRECTOR OF RESOURCES

Dr. COLLADAY. Thank you, Mr. Chairman.

It is a pleasure to be here this morning to present to you the advanced technology portion of NASA's fiscal year 1987 budget request.

I have a written statement, Mr. Chairman.

Senator GORTON. We will include the written statement in the record as if you had read it in full. If you will highlight it for us, we would appreciate it.

Dr. COLLADAY. Thank you. I will limit my remarks to the highlights and a brief summary. This year's budget request includes $376 million for aeronautical R&T and $45 million for transatmospheric R&T which is NASA's portion of the new National Aerospace Plane Program, a joint effort between the Department of Defense and NASA.

The request reflects the strongest commitment that this administration has made in aeronautics, and specifically in the NASA program as a source of independent far—term R&D that is a vital element of the coordinated national R&D partnership that is dealing with the national goals as enunciated by the recent report of a year ago on the national R&D agenda for this country.

I am pleased with the budget that this program provides. I think it is bold and visionary, and I think it will prove to be extremely important to this country in the years to come. In the face of unprecedented challenges to U.S. preeminence, the highest leverage for U.S. leadership is our pioneering new technology. While competition provides the pull on technology, the push, no less important, comes from knowing that there are enough key technologies that are emerging from our research laboratories right now to make virtually every operational aircraft in service today obsolete in a short period of time.

In order to accomplish the kind of objectives that we have for targeted opportunities, we need to pull together, in a coordinated way, the R&D efforts of this country. The report on the national R&D goals that was published just a year ago serves that purpose. Could I have the first slide, please?

[Slides shown during oral presentation.]

Dr. COLLADAY. The goals themselves as depicted here include three vehicle types and an underpinning of revitalizing basic R&T for aeronautical research. The goals themselves are not remarkable. What is remarkable is that they represent a consensus reached by Government, industry, and universities in a partnership for conducting advanced R&D for aeronautics. The coordination and cooperation that led to these goals enunciated a year ago has carried over into the cooperation between the Department of Defense, NASA, and the industry into the centerpiece of these three vehicle goals as represented by the National Aerospace Plan Program that I will come to in more detail in a few minutes.

The NASA program is responsive to these national goals and is concentrating heavily on emerging technologies that have an order of magnitude improvement potential in performance.

Taking the first goal of subsonic technology, the key technologies have long been known. They are ultrahigh bypass ratio engines, lightweight structures, digital controls, high aspect ratio airfoils as shown in this configuration, and maximized natural laminar flow configurations.

We have been working many of these technologies jointly with the industry for a number of years. Many of them have been completed as a result of the Aircraft Energy Efficiency Program that was started in the midseventies. Of particular importance in this set of technologies is the advanced turboprop program, more commonly known as PROPFAN or ultrahigh bypass ratio propulsion.

It is the single largest technology that impacts fuel conservation and fuel efficiency in future subsonic transport aircraft.

We intend to complete the planned flight test for the highspeed turboprop in early fiscal year 1987. As the industry effort builds up with a promise that this technology provides, NASA has rescoped the program to provide the key essentials that the flight program is intended to demonstrate in scaling effects from the small diameter wind tunnel models to full-scale flight configurations, but some of the program has been descoped that was planned for later in subsequent flights.

I assure you, however, that we will meet the flight schedule that was originally laid down some 3 years ago for the key scaling effects that the flight program provides. Also, in fiscal year 1986, the test of the unducted fan counterrotation configuration will be completed, and plans are for the industry to proceed with flight testing of that configuration.

On into the future, we will continue to do basic research addressing acoustics and configuration aerodynamics and installation aerodynamics that are crucial to different approaches to incorporating this advanced propulsion system on future aircraft. In all of these national R&D goals, we address and undertake, when appropriate, major systems technologies like the advanced turboprop program to accelerate technology readiness in high payoff areas. But underpinning these more visible projects is a basic research effort across the board on many fronts that provide the foundation for advances of the more visible systems projects. And we will continue to pursue that fundamental research, for example, applying the experience in computational modeling to a serious safety problem in wind shear.

We have analytically predicted the flow associated with wind shear and microbursts and the ground effects of aircraft in final approach, as shown here. In the configuration in this figure, the forward velocity of the oncoming airstream near the ground created from a microburst can change suddenly into a tailwind that affects the lift of the aircraft. In order to model that behavior, we are applying our computational methods and have successfully done so as shown in the upper right hand corner of that figure, and then that input is in turn made available for our ground based simulators for pilot training and overall aircraft behavior in these severe storm conditions, and looking at heavy rain effects and the response to the aircraft with these kind of microburst characteristics.

While still on the subject of the subsonic goal, I must mention rotorcraft as an important element of that first goal in subsonic aircraft, and in the fiscal year 1987 budget that is before you we plan to accelerate technology of a very fundamental nature in noise and vibrations for rotorcraft in an extremely important area that promises an 80-percent reduction in noise and vibration in future rotorcraft systems.

The second goal of the three vehicle class goals in the OSTP goal report is long-distance supersonic cruise. I would say that our crystal ball for supersonic cruise is the most cloudy. We know what the key technologies are that need to be addressed if this is to be a successful operational vehicle for transport aircraft. It is subsonic or supersonic laminar flow, high temperature variable cycle engines and high temperature composite structures that can yield a lightweight efficient overall warm structure, but how these technologies should be merged into an aircraft system and what the economic payoffs for such a vehicle are is uncertain at this point. Those are issues that we intend to address through the award of definitive studies to the airframe companies and the engine companies that would be involved over this next year. To address aircraft conceptual design, tradeoff studies between speed, size, range, and fuel characteristics, the economics and market needs of such an aircraft, and environmental issues. We think that these definitive overall trade studies will provide a roadmap for the technologies that need to be worked in the supersonic cruise R&D goal.

The third goal of the set of three in transatmospherics brings me to the National Aerospace Plane Program, part aircraft, part spacecraft. The aerospace plane would take off and land on conventional runways, accelerate through transonic and then supersonic speeds to hypersonic cruise, and then with appropriate thrust assist on into orbital velocities and on into space.

The program has been enabled by a base of fundamental technology that has come out of the research laboratories in this country over the last 10 years, and in many of the key technical areas we have been pursuing in the aeronautics and space technology programs in NASA, DARPA has focused that technology over the last several years and accelerated certain elements of it to the point where we now think it is feasible, though challenging, to take this next giant step toward a vehicle that could write a new chapter in air and space travel.

As the President has mentioned in his state of the Union address, commercial transport using this technology could provide routine access to the Pacific Rim countries. As a military aircraft it would have unprecedented performance, and as a launch vehicle it could provide major reductions in delivering payloads to orbit. The technology that would be demonstrated in an experimental vehicle would provide the framework for a whole class of operational vehicles, all having the same pedigree in the technology.

The Aerospace Plane Program is focused on accelerating technologies in this next phase, phase 2, pointing toward a decision point in late 1989 before proceeding to the experimental aircraft phase—or experimental vehicle phase in phase 3—as shown on this chart. The basis for the program is established in phase 1, where we undertook a focused review and effort on critical technologies that have come out of the aeronautics and space R&T programs and other programs in industry and the Department of Defense.

In the timeframe that is shown for the Aerospace Plane Program, you can see that the target is for validating the technology through a flight research effort in the 1992 to 1995 timeframe. In parallel with that, a number of application studies would be ongoing to address the operational vehicle characteristics that this technology would enable.

It is important to put the technology program and the flight research effort into proper context, however, and realize that after the technology is demonstrated in the Aerospace Plane Program, one has to then proceed with an operational vehicle development that would range from 5 to 7 years beyond that, so that we are talking about having the technology in place to enable an operational vehicle, launch vehicle, or hypersonic cruise transport in the year 2000 or beyond.

The list of key technology challenges in this program is long indeed. But at the top of the list, propulsion has to be the cornerstone of the capability of the vehicle. We have been assessing and doing research on SCRAMJET propulsion. It is key to the overall performance of the engine system for this vehicle for the last decade. Shown in this figure is a test article mounted in the hypersonic tunnel at Langley that shows a single SCRAMJET module where we have done some 1,100 tests of different configurations on the supersonic combustion ramjet configuration.

You can see the channel in the throat region, the hydrogen fuel injection ports, and we have demonstrated net thrust sufficient to propel a vehicle at hypersonic speeds, and on towards orbital velocities.

Other key technologies on that list include high strength materials and advanced structures that can withstand the extreme heat loads occurring during sustained hypersonic flight, where temperatures will exceed, over long periods of time, 2,000 degrees, and during ascent and descent from orbit where peak stagnation temperatures can exceed 5,000 degrees. That is extremely challenging considering the fact that just inches away from the surface we also have to house liquid hydrogen fuel that is at a temperature of minus 430 degrees.

We have been looking at a number of configurations and advanced materials, and that will be a major part of the research and technology program in the aerospace plane joint effort. Another key technology on that list is the integration of the propulsion system in the airframe, and key to that is our ability to predict analytically the flow fields in highly accelerating reacting boundary layers typical of hypersonic flight.

The numerical aerodynamic simulation [NAS] capability that has been developed in the aeronautics program over the recent years is coming into operation just at the right time to be able to apply advanced codes for the computation of fluid dynamics needs of the aerospace plane.

The NAS, as we refer to it, will be fully operational in July of this year. The first high speed processor of that computer system is the CRAY II supercomputer, and it has more memory than all the CRAY machines of the 1S and the XMP vintage that have been sold to date by Seymour Cray and the Cray Co. It is the world's most advanced computer applied to computational aerodynamics, and it will be crucial in the development of the vehicle design for the aerospace plane.

The integration of the propulsion system in the airframe, as I mentioned, is critical, and we have a limitation on the Mach number range that can be accommodated in ground-based facilities. That makes the aerospace plane the centerpiece of that program, a research vehicle that we can test under flight conditions of a fully integrated system, the overall performance of the hypersonic and airbreathing to orbit conditions. Experimental airplanes and vehicles are not foreign to us. We have done joint programs with the Department of Defense and NASA, and before at NACA, a number of X series vehicles, the X-15, in the 1950's and the lifting body X series shown here.

The X-24 vehicle provided the technology base for the shuttle design, and a number of other vehicles have been done in support of aeronautics vehicle developments. The most revolutionary of this whole series of X airplanes will no doubt be the aerospace plane, and it will have a number X-30 or X-31, depending on when that selection of number code is made.

Finally, in just summarizing, the budget that we are presenting, the budget request to you for aeronautics, includes the $376 million that are referred to in the aeronautics R&T, and that is broken into R&T base and systems technology as shown on this slide and the transatmospheric R&T which is NASA's portion of the National Aerospace Plane Program. That is a new line item in the budget beginning this year to focus the technology that has been evolving in the aeronautics base as well as the space research and technology, and to show the commonality between the focused transatmospherics R&T with the base technology.

I have also included the space R&T line on that chart. Time does not permit me to go into a number of the emerging technologies that we are pursuing in the R&T base there. They are exciting, and they promise to lead to breakthroughs in vehicle performance no less dramatic than the aerospace plane.

As I said in the beginning, I believe that the program is sound and is making major contributions to the whole R&D process in this country. It is a partnership that is undertaking the R&D goals that have been enunciated by this administration. It is a working and cooperative partnership with industry, universities, and across the government.

I believe that we are focused on the right technical challenges. The NASA program is long term. It is high risk. But the payoffs are immense. It is focused on emerging technologies with order of magnitude payoff potential. There are tough programmatic decisions that need to be made, and we realize that we cannot pursue all of the attractive opportunities. We cannot afford to pursue areas with only small incremental gains, no matter how important those are.

Good, sound research will have to be curtailed in order to move to higher payoff activities that will lead to breakthroughs in the future. The aerospace plane is a good example to show the dynamics of the technology that has developed in the front end of the fundamental base R&T as it emerges to large systems programs like the aerospace plane promises to be.

The Congress has been a staunch supporter of NASA's aeronautics program over the years—at times when that support was crucial to its very existence. The payoff of that support coming from the research program is just now beginning to be realized, and I think, Mr. Chairman, without question you will not be disappointed in the results of that sustained support over the years.

That completes my prepared statement, and I would be happy to answer any specific questions you might have. I have my budget director here, Mr. Sanchez, and staff that can assist me in addressing any of those questions.

Senator GORTON. Thank you, Dr. Colladay. You have answered this question, I believe, in a way that I will have to call technical jargon, but let us get down to a very simple question. The space plane differs from the shuttle among other things, I gather, in having all of its power self-contained. There will be no external tanks or external rockets or the like in the powerplant.

Dr. COLLADAY. That is correct. The principal feature of the air breathing propulsion system is that it acquires its oxygen from the atmosphere as it accelerates and propels through the atmosphere, skimming at the top of, before going into space and as a result does not have to carry liquid oxygen as the shuttle does.

Senator GORTON. And therefore it will take off from a conventional strip the way an airplane does rather than from a launched pad and tower, the way the shuttle does at the present time?

Dr. COLLADAY. Horizontal takeoff and horizontal landing from a conventional runway with features typical of aircraft. Yes, sir.

Senator GORTON. Obviously, when the Congress is asked to start a new program of this nature, questions arise as to costs and as to budgets. You will recognize that we have now taken the first step toward a budget for fiscal year 1987. Given the kind of constraints under which we are operating at the present time, how would you state as simply as you possibly can the compelling reasons for beginning this program now and the kind of requirements which are driving it?

Is it true that this really is the next generation orbiter and that there is no logical next manned launch vehicle between our present shuttle in between what we are doing right now and the vehicle which is the goal of the National aerospace plane Program

Dr. COLLADAY. Well, the timing on the program is a match between the requirement to have a capability that could be in place for the next generation shuttle as well as the feasibility that the technology itself has proven that now it is feasible to move forward. The aerospace plane does offer the potential to be the next generation shuttle, and the timing is such that if we undertake the program now, and demonstrate the feasibility through a flight vehicle by 1995, we could have an operational launch vehicle in place by the year 2000 which is the timing when we have to consider replacing the current shuttle.

Senator GORTON. So we are looking, if we start this year, at having something which would replace the shuttle at best by the year 2000?

Dr. COLLADAY. That is correct.

Senator GORTON. This is a mixed military and civil program, obviously. The next witness will be speaking on behalf on the Department of Defense.

Specifically what are the civil applications coming or likely to arise out of this program? To what extent and for how long will it fulfil our future space transportation system requirements?

Dr. COLLADAY. The civil applications are, in addition to launch vehicle, operational vehicle that I have already mentioned, also includes hypersonic transport aircraft, which at some point in our future offers a potential for a vehicle that would go considerably beyond the supersonic transport area.

The timing for that is uncertain.

Senator GORTON. You would not be building this just in order to get to Tokyo in 2 or 3 hours?

Dr. COLLADAY. I do not see that as an early application at all. I think the principal application early on will be for certain military applications and as a launch vehicle, low-cost delivery of payloads to orbit.

Senator GORTON. How low a cost? What kind of cost do you anticipate for the delivery of low-orbit cargo as compared with the cost of using the present shuttle?

Dr. COLLADAY. I think we are looking at costs that can be reduced by a factor of 10 and maybe considerably higher than that, as high as perhaps even a factor of 100 reduction over the shuttle. I think that is a little optimistic.

Senator GORTON. A huge difference?

Dr. COLLADAY. A huge difference.

Senator GORTON. You have spoken of a number of technological challenges that we face. If you could put your finger on one as the key technology for achieving your objectives, what would that be?

Dr. COLLADAY. Propulsion has to be it. The whole key to the vehicle is a propulsion system, a propulsion system that can operate efficiently from zero velocity to Mach 25 orbit insertion.

But the other technology challenges are not far behind that.

Senator GORTON. Let us go back to what you said was a much longer range objective and one offshoot of the hypersonic vehicle in the future world of commercial aviation activity. How much of this program is directed at that objective, and do we have any real assurance that we are simply not talking about another Concorde, from the point of view of economic viability?

Dr. COLLADAY. This has a number of features that I think make it, as a transport aircraft, more economically viable than the Concorde vintage supersonic transport. You cannot partition the technology that we are developing for the aerospace plane into a civil transport and a hypersonic military aircraft or a launch vehicle.

What we want to do is construct a program that develops the technology and demonstrates it in an experimental vehicle that can provide the foundation for a whole host of operational vehicles that would branch off from that, all having the same pedigree in the aerospace plane program.

The timing of when such vehicles would become operational, whether they even would, based on overall economics, would depend upon studies that have to be done long after the technology is demonstrated in the X airplane.

I think that the early applications, though, are going to be in terms of a launch vehicle and certain military applications. But the transport aircraft or a commercial civil transport will be enabled as well by the technology proven in this effort.

Senator GORTON. What about competition? Do we have competition in this connection from the Soviet Union, the European Space Agency, from Japan? In connection with the latter two, is there any possibility, as with the space station, that we may eventually be entering into a cooperative effort?

Dr. COLLADAY. We are following closely the work of our potential adversaries, as well as potential partners that might be considered in the future. We are certainly not the only ones working on the technologies that would enable such a vehicle. We know that the Soviets have long been pioneering work in supersonic combustion ramjet engines, and as I said that is a key to the propulsion system.

We of course are aware of what the United Kingdom is doing with the horizontal takeoff and landing space vehicle and what other countries are doing. We are on a different technology path than what the HOTOL is pursuing, and at this point we have not sought collaboration with them.

Senator GORTON. A different technology path? Describe that?

Dr. COLLADAY. A different technology path in the propulsion system. We think the propulsion concept for an integrated system in the aerospace plane is different and far superior to the configuration is the horizontal takeoff and landing vehicle that the United Kingdom is pursuing.

We are also addressing technology development in systems very similar to what that vehicle will have in our airturboramjet research between DARPA and NASA and other combined hybrid engine systems that show promise for certain classes of vehicles. But that is different from what we're pursuing in the aerospace plane.

Senator GORTON. Are you confident that the technologies we are looking for through the phase 2 study are achievable, that there is no possibility that we may be running into a dead end?

Dr. COLLADAY. I do not believe we are running into it, we are on a path that is dead end. I think, while the technology challenges are immense, I think we are confident that there are engineering solutions to those technical challenges. And with persistence, we can achieve the objectives of the program. It will not be easy. We are taking a step that is probably bigger than any single technological step that we have taken on programs in my memory.

But I think we can achieve the goals of the program.

Senator GORTON. How many research vehicles is this likely to require?

Dr. COLLADAY. Well, the plan is for two vehicles, which is a common procurement approach for X airplanes like this, where the risk is as high as this, to have a primary vehicle and a backup. Whether those two vehicles would have identically the same technology incorporated within them is not certain at this time.

One could envision a serial arrangement, where the second vehicle accommodated more advanced technology than the first.

Senator GORTON. From a monetary contribution point of view, I understand—and correct me if I am wrong—that NASA is going to put 20 percent into it, the Department of Defense 80 percent. Is there any rational ground for that distribution of the contribution, or is this just what you figure the ease of dealing with Congress requires?

Dr. COLLADAY. Well, from my standpoint it is a pretty good deal.

Part of that 80–20 percent split can be explained by understanding that there are four elements to the Department of Defense and one NASA. Roughly speaking, each of the partners are putting in equal amounts of roughly 20 percent each, and that is a simplistic way of building up the 80- and 20-percent response.

Now, in addition to the 20 percent R&D budget that NASA shows against the program, you will understand that the facilities and the computers that we will make available as far as our institution of NASA is concerned are of an amount probably equal to that R&D amount in the budget.

We have a number of wind tunnels that will be pressed into service in this program. The whole program in aeronautics and space technology, where we have got a cadre of people dedicated to this effort, as well as the NAS computer that I mentioned and other computers will be made available, as they should, as a national resource for this program.

So that is what we are bringing to the table in addition to the focused R&D budget that is there.

Senator GORTON. One question on the ATP program. According to your testimony, because of increased industry activity in that work, NASA's single rotation flight test has been reduced and the cabin environment investigation has been eliminated.

Are we giving something up in this program modification? Will there be significant gaps in the data base of the program as a result of these modifications?

Dr. COLLADAY. Well, you have to look at that program in the context of the companion efforts that are proceeding in parallel that the industry is doing. And on a national level, I would say that there will not be any gaps.

I think acoustics is key and it will have to be addressed and will be addressed in the flight test programs that the industry is doing, as well as our fundamental research that will be going on in parallel to our flight test.

Senator GORTON. Thank you, doctor. I have at least a dozen other questions here, but we have other witnesses this morning. We will submit the balance of our questions to you in writing.

I believe there will also be other questions from other members of the committee on both sides, and we would appreciate your answers to those questions as promptly as possible so that we can move forward.

Senator GORTON. With that, we want to thank you for your testimony this morning and for your cooperation and for your vision.

Dr. COLLADAY. Thank you very much, Mr. Chairman.

[The statement and questions and answers follow:]

STATEMENT

OF

Dr. Raymond S. Colladay
Associate Administrator for
Aeronautics and Space Technology

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. Chairman and Members of the Subcommittee:

It is a pleasure to appear before you today to present NASA's FY 1987 Aeronautics and Transatmospherics Research and Technology (R&T) budget requests. This request reflects the Administration's continuing strong commitment to aeronautics in this difficult fiscal environment. The NASA R&T base is a vital element of a coordinated, National R&D effort. As a source of independent, far-term R&T, it provides new concepts, innovative ideas, and generic technology essential to U.S. leadership in aviation.

Today, we are facing unprecedented challenges to U.S. preeminence in aeronautics and space from industrial competitors and military adversaries. During this past year, the White House Office of Science and Technology Policy announced the establishment of National Aeronautical R&D Goals designed to focus U.S. R&D in high-payoff technology areas that will sustain the nation's aeronautical preeminence into the 21st Century. The highest leverage for securing lasting U.S. leadership is through America's traditional strength: pioneering new technology. In fact, aeronautical opportunities are now known that could enable us to technologically supercede virtually all significant military and civil aircraft operational today.

As you know, three specific goals, shown in Figure 1, were set forth: 1) to advance technology for a new generation of fuel-efficient subsonic aircraft, 2) to develop pacing technologies for efficient, long-distance supersonic cruise, and 3) to secure future options by pursing research towards the capability for transatmospheric flight. Also highlighted was an essential strategy to revitalize basic research and technology. These goals have provided a framework for setting new directions in the NASA aeronautics program. The program is responsive to the National Goals and is concentrating heavily on emerging technologies which promise order-of-magnitude advances.

For the greater part of this century, NASA and its predecessor NACA have pioneered advanced technology for superior U.S. aircraft. This sustained long-term, fundamental research activity has yielded great payoffs for the nation, frequently leading to revolutionary new vehicle systems or capabilities. Despite the remarkable progress to date, we are now on the threshold of numerous exciting opportunities for making dramatic leaps in vehicle capabilities. Impressive progress is being made in computational fluid dynamics and structures. Recent breakthroughs are enabling realistic calculations of internal flows for propulsion applications and 3-dimensional flows about complete aircraft. Structural simulation of entire aircraft with detailed local analysis will soon be possible. Coinciding with advances in computational methods is the initial operation of the Numerical Aerodynamic Simulation (NAS) capability which is developing the world's premier scientific computational facility for aeronautical research and development. When fully operational in July 1986, this capability will greatly accelerate progress in computational fluid dynamics as well as in other important computationally intensive disciplines such as structures, materials, and chemistry. Innovative results are also rapidly emerging from our research laboratories in the areas of super-maneuverable aircraft technology; lightweight, high-temperature materials; and hypersonics, where great progress has been made in airbreathing propulsion. These advances in technology have profound significance for the future of aviation.

I would now like to touch briefly on a few items in the FY 1987 budget request that address achievement of the National Goals or have special potential for affecting our military and civil capabilities as well as the U.S. competitive posture.

Transatmospherics R&T

Perhaps most visibly, these advances in aeronautics and space technologies are enabling an entirely new class of aerospace vehicles, powered by airbreathing propulsion, that have vastly superior performance to anything flying today. The Aerospace Plane as shown in Figure 2 -- both an aircraft and a spacecraft -- will be capable of taking off from and landing horizontally on conventional runways, sustaining hypersonic cruise in the atmosphere, and accelerating into space. As the President mentioned in his State of the Union Address, a commercial transport using this technology, could be developed, providing routine access to the Pacific nations in less than two hours. The extreme altitude and speed capability of this technology will make our military aircraft nearly invulnerable to attack and initial indications are that such transatmospheric vehicles will significantly cut the cost of delivering payloads to orbit. This exciting opportunity is a direct outgrowth of long-term, fundamental research in the NASA aeronautics and space R&T base, maintained over the past decade. Major technical advances have occurred which have provided the confidence for significant growth and acceleration of technology development for an aerospace plane.

NASA is requesting $376.0 million in FY 1987 for Aeronautics R&T and $171.0 million for Space R&T as shown in Figure 3 compared with previous years' budgets. Transatmospheric R&T, which is an integral part of the joint NASA/DOD National Aerospace Plane program, is a new budget line item for FY 1987. This request of $45.0 million for focused transatmospheric R&T is building on a strong base of fundamental research being conducted in the aeronautics and space R&T programs.

The NASA transatmospheric activities include a combination of computational efforts, ground-based experiments, and small-scale hypersonic flight experiments (a joint effort with Sandia National Laboratories). The Aerospace Plane program elements, highlighted in Figure 4, are focused on developing and validating the critical technologies. The key enabling technology is airbreathing propulsion. Propulsion concepts for this application must function efficiently over a wide speed range -- from zero speed for takeoff to Mach 12 or even to near orbital velocities. Hybrid engine concepts have been identified that when integrated with a supersonic combustion ramjet or SCRAMJET have the potential to perform effectively over the entire speed range. The airframe and propulsion system must have high strength and low weight thermal structures to withstand repeated exposure to extreme heating loads during sustained hypersonic flight in the atmosphere. For ascent into orbit, peak temperatures could rise to 5000°F in some areas, requiring the development of advanced materials and active cooling technology. Perhaps one of the greatest challenges for this class of vehicles is the integration of the highly interdependent airframe and propulsion system. The maturation of key technologies including the development and testing of propulsion system modules and airframe components will lead to an assessment of technology readiness in 1989, prior to any decision to proceed with an experimental aircraft. During FY 1987, comprehensive design studies involving the aerospace industry will explore the application of these and other advanced technologies to future high-speed civil transportation systems.

Recent accomplishments that enable realistic consideration of these ambitious goals are flowing from many key technology areas. Langley Research Center has demonstrated, up to the ground test facility limit of Mach 7, sufficient SCRAMJET engine thrust (Figure 5) to propel a large aircraft at hypersonic speeds. Two of our major facilities for propulsion testing are currently being modified to expand their capabilities; the 8-foot High Temperature Tunnel at Langley for large-scale and multiple-module SCRAMJET tests and the Propulsion System Laboratory (PSL) at Lewis Research Center for subsonic and supersonic system tests. An advanced carbon-carbon material has also been developed with high-emissivity, oxygen-resistant coatings. These materials promise substantial weight reduction for high-temperature leading edge and control surface structures. Techniques for foil-gage fabrication and vacuum sealing of superalloy (Figure 6) and metallic composite structure have also been improved sufficiently to consider in the design of lightweight, hot structures for airframes and engines.

The advanced NAS capabilities are becoming available just in time to support the enabling CFD analysis and design activities for the National Aerospace Plane program. The NAS facility at the Ames Research Center and other large supercomputers will provide the necessary computing power to analyze the complex flow interactions of airbreathing propulsion systems and external aerodynamics. Important advances in computational modeling provide the ability optimize the configuration and propulsion system integration and to analyze the transatmospheric class of vehicles in areas where ground test facilities are inadequate.

Extending research from experiments in the laboratory to flight has long been recognized as a necessity for the development and validation of hypersonic/transatmospheric technology, since ground test facilities are inadequate. Notable examples begin with the development and flight test of the X-15 (Figure 7) in the 1950's, the lifting body (Figure 8) programs in the 1960's, and most recently the Space Shuttle. This extension to flight will be particularly necessary for the aerospace plane, where integration of the highly interdependent airframe and propulsion system and vehicle performance validation throughout this broad flight envelope will eventually require an experimental aircraft, or X-vehicle. With the potential for a major revolution in air and space transportation at hand, NASA plans to move very aggressively.

Long Distance Supersonic Cruise

In the second goal area, the NASA Supersonic Cruise Research (SCR) program advanced the technology base during the 1970's far beyond the Concorde and U.S. SST designs. Yet the supersonic perspective still remains bright. Key technology opportunities including supersonic laminar flow, high-temperature, variable cycle engines, and lightweight warm structures promise an economically viable transport aircraft (Figure 9) with higher cruise speeds and 200-300% improvement in fuel efficiency relative to Concorde. However, today there is no strong national consensus on a civil supersonic cruise airplane. Since the end of the SCR program in 1981, NASA has maintained a low level-of-effort in the critical technologies, and our budget request for FY 1987 maintains this effort. There is also significant synergism and applicability of fundamental disciplinary research as well as the high performance aircraft and engine hot section technology activities. In addition, design studies involving the aerospace industry will explore the needs, economics, and the application of Aerospace Plane and other advanced hypersonic and supersonic technologies to future high-speed civil transportation systems.

Subsonic Technology

The prospects for subsonic aircraft technology over the next 20 years far exceed the evolutionary advances of the past 20 years, providing the potential for a new generation of aircraft (Figure 10) with clearcut superiority. Major NASA and industry technology programs are already well underway, as prior major investments such as the Aircraft Energy Efficiency (ACEE) Program rapidly mature the key technologies and industry accelerates technology readiness for product application in the early 1990's.

Of particular importance is the advanced turboprop which represents the single largest contribution to improved aircraft fuel efficiency. The NASA Advanced Turboprop (ATP) program (Figure 11) is progressing toward an early FY 1987 flight test of a large-scale, single-rotation propeller to provide scale verification of the blade structures, aerodynamics, and acoustics. Large-scale ground tests of the General Electric Unducted Fan, a gearless counter-rotation concept, will be completed this year. The technology base developed during the past decade in the NASA program has resulted in a rapidly expanding industry effort. In light of the accelerating industry activities, the ATP program for FY 1987 and beyond is being modified. The single-rotation flight test activity has been reduced and the acoustically treated cabin environment investigations have been eliminated. However, the modified NASA ATP program, with expanded participation by industry, will provide the fundamental data base and technological foundation necessary for future industry product development.

NASA is applying experience in computational modeling to the serious safety problem of low-altitude wind shear occasionally experienced by aircraft during takeoff and landing. Analytical models, such as presented in Figure 12, permit the calculation and display of microburst airflows and their interactions with aircraft. In FY 1987, NASA and the FAA plan to pursue a cooperative research program addressing airborne wind shear detection, avoidance, and survivability. Emphasis will focus on characterizing the microburst phenomena, determining heavy rain effects on aerodynamic lift, and improving aircraft response in severe wind shear.

In a related subsonic area, the NASA rotorcraft R&T program is focusing on key problems that severely limit the vehicle's civil and military usefulness. The rotorcraft program will be augmented in FY 1987 to develop and verify accurate prediction methods and to explore new concepts for an eighty percent reduction of noise and vibration. This program builds on cooperative basic research with industry and the U.S. Army conducted over the past three years. In addition, the X-Wing program will be reaching an important milestone in FY 1987. The X-Wing concept, pictured in Figure 13, has the vertical lift capability of helicopters while providing the range and speed abilities of fixed-wing aircraft. The primary objective of the joint DARPA/NASA Rotor Systems Research Aircraft (RSRA)/X-Wing flight test program is to demonstrate X-Wing conversions from rotary- to fixed-wing flight and back to rotary-wing flight. A forty hour flight test program will be initiated in early FY 1987 and completed in August 1987.

Emerging Technologies

In addition to these areas, there are remarkable opportunities in aeronautics technology for making order-of-magnitude advances in future vehicle capabilities. A broad program of basic R&T focused on emerging technology is essential if these new advances and breakthroughs are to occur. This will also lead to additional and perhaps even more important developments which are just now being identified.

An area of extreme importance for analysis and optimization of all future vehicles is numerical simulation. Impressive progress is being made in computational fluid dynamics (CFD) for both internal (propulsion) and external (aerodynamic) flows. Future efforts will center on extending the propulsion analysis to a full three-dimensional flow simulation which will have a major impact on compressor/turbine performance, and on the efficiency and reliability for both airbreathing and rocket propulsion systems. We are now also aggressively pursuing viscous flow simulation and experimental verification about complete aircraft, a capability which is crucial to the design of the Aerospace Plane and highly integrated military aircraft. Progress in CFD is expected to accelerate as the Numerical Aerodynamic Simulation (NAS) capability becomes fully operational in July 1986. All elements of the Initial Operating Configuration (IOC) have been installed and successfully acceptance tested including the new Cray 2 supercomputer (Figure 14). The NAS machine is currently the world's largest and most powerful scientific computer and will provide a national capability for computational solutions to complex fluid flow and structural problems.

The exploitation of NAS and the next generation of large-scale parallel processing computers for structural analysis will enable more efficient, lightweight, and cost-effective aerospace structural systems. A growing computational structural mechanics activity is concentrating on the development of numerical techniques to analyze and optimize a complete aircraft structure, including the capability for local detailed analysis of critical components within larger computational models.

In FY 1987, NASA will also expand research for advanced composites, focusing on a new generation of materials and design approaches for up to a fifty percent weight reduction over existing structures. Significant effort will be devoted to the development of advanced concepts and configurations which exploit the unique properties of composites. In addition to the development and characterization of new thermoset and thermoplastic resin systems, research will concentrate on effectively using advanced material forms and fabrication technology, such as 3-dimensional weaving, to increase damage tolerance and strength.

In an area which promises a leapfrog in future military aircraft performance, the Langley Research Center has established the feasibility of propulsive flight control as a design option through simulator and free flight tunnel research. This concept is the result of many years of NASA research into fighter aircraft aerodynamics and controllability at high angles-of-attack. Results include safe maneuvering flight at angles-of-attack approaching 80 or 90 degrees, as demonstrated by the F-18 model in Figure 15, and highly efficient supersonic cruise designs. NASA plans to accelerate the development of the key enabling technologies.

Summary

The NASA research establishment has required decades to develop, and has played a major role in establishing and maintaining U.S. leadership in aeronautics. We have a strong commitment to continuing NASA's central role in research and technology. The foundation for future contributions is the excellence of our institutional capabilities. With the constraints on the federal budget, we can neither pursue all attractive opportunities nor be lulled into seeking small incremental gains. Tough programmatic decisions will continue to lead to curtailment or even elimination of good research in favor of even higher payoff activities. The NASA aeronautics program is identifying and concentrating on key emerging technologies that promise order-of-magnitude advances. As we look at where those advances are likely to occur, I expect that we will continue to put more emphasis on the high-speed flight regime to extend U.S. leadership in aeronautics and space.

It is essential for the continued growth and prosperity of U.S. aeronautics that government, industry, and universities approach our aeronautics future with vision. The recently established National Aeronautical R&D Goals provide a framework for focusing planning and research efforts. I believe that the FY 1987 budget request will enable NASA to continue to provide the necessary technological foundation and leadership for securing the exciting capabilities we have described. We appreciate this Committee's long-standing support and commitment to aeronautics research, and look forward to working with you to strengthen this area that is so crucial to the future economic and defense security of this country.

Thank you Mr. Chairman.

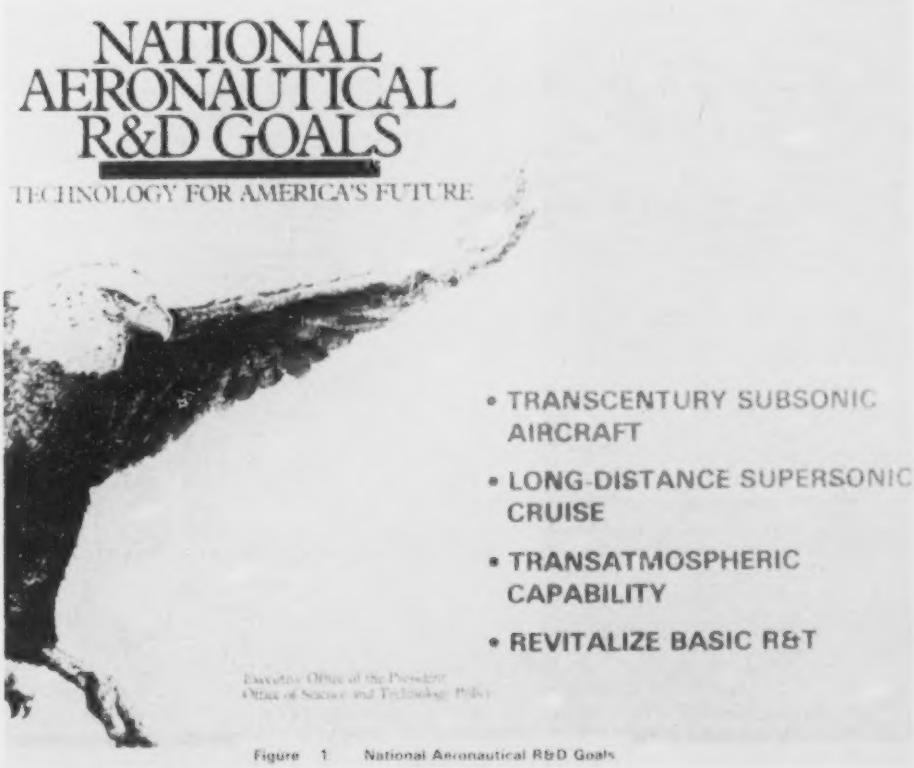

NATIONAL
AERONAUTICAL
R&D GOALS
TECHNOLOGY FOR AMERICA'S FUTURE
• TRANSCENTURY SUBSONIC AIRCRAFT
• LONG-DISTANCE SUPERSONIC CRUISE
• TRANSATMOSPHERIC CAPABILITY
• REVITALIZE BASIC R&T
Executive Office of the President
Office of Science and Technology Policy

Figure 1 National Aeronautical R&D Goals

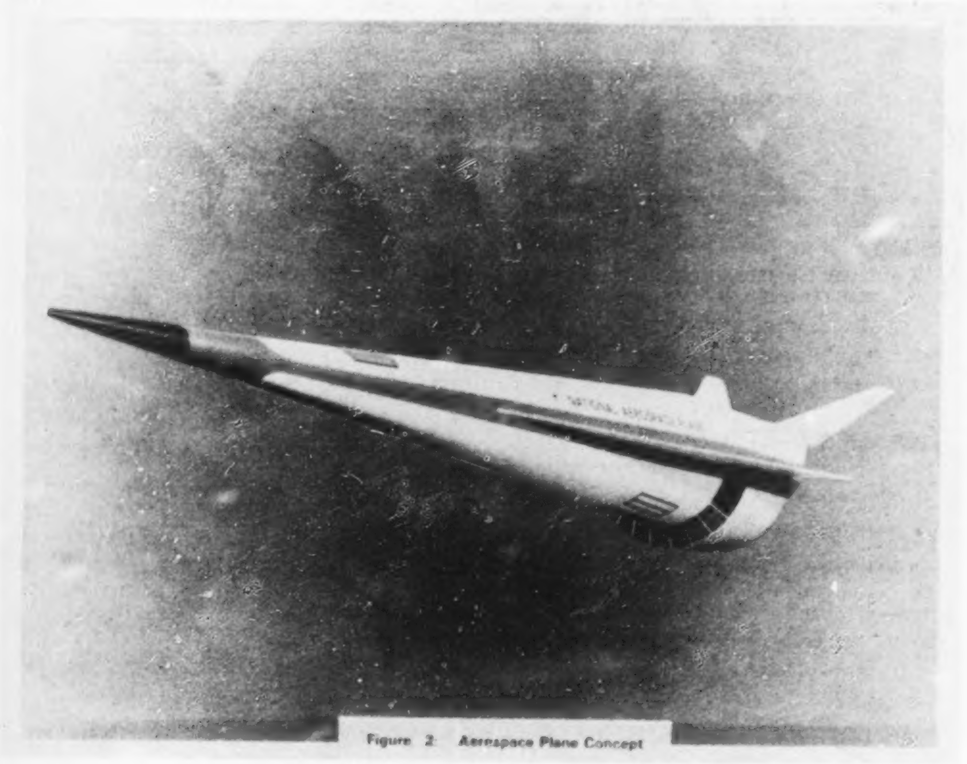


Figure 2: Aerospace Plane Concept

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

R&D BUDGET

	$, MILLIONS			
	FY 1985	FY 1986		FY 1987
	ACTUAL	BUDGET ESTIMATE	CURRENT ESTIMATE	BUDGET ESTIMATE
AERONAUTICS RESEARCH & TECHNOLOGY	342.4	354.0	354.0	376.0
R&T BASE	(223.3)	(239.3)	(240.3)	(272.9)
SYSTEMS TECHNOLOGY	(119.1)	(114.7)	(113.7)	(103.1)
SPACE RESEARCH & TECHNOLOGY	145.1	160.0	160.0	171.0
TRANSATMOSPHERICS R&T (NATIONAL AEROSPACE PLANE TECH.)	–	–	–	45.0

Figure 3: Aeronautics, Space, and Transatmospheric R&T Budgets

AEROSPACE PLANE TECHNOLOGY ROADMAP

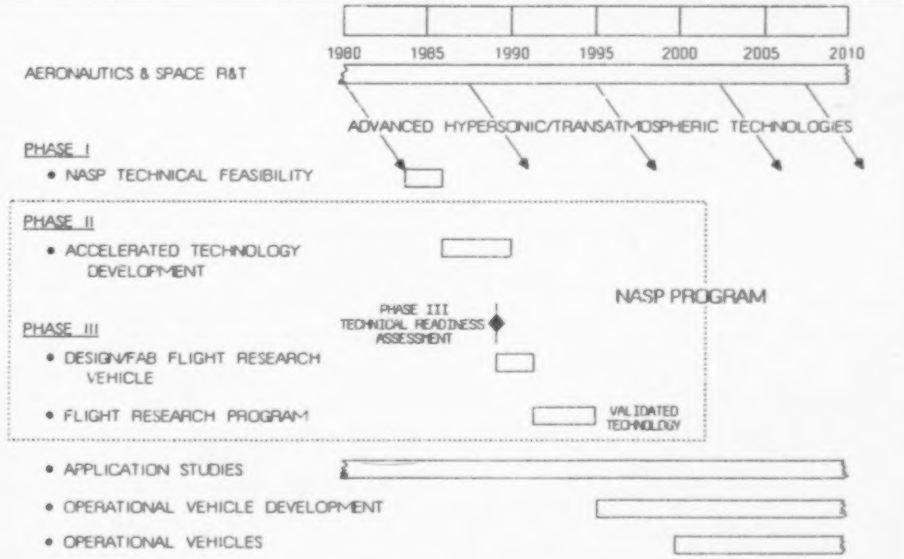


Figure 4: National Aerospace Plane Program

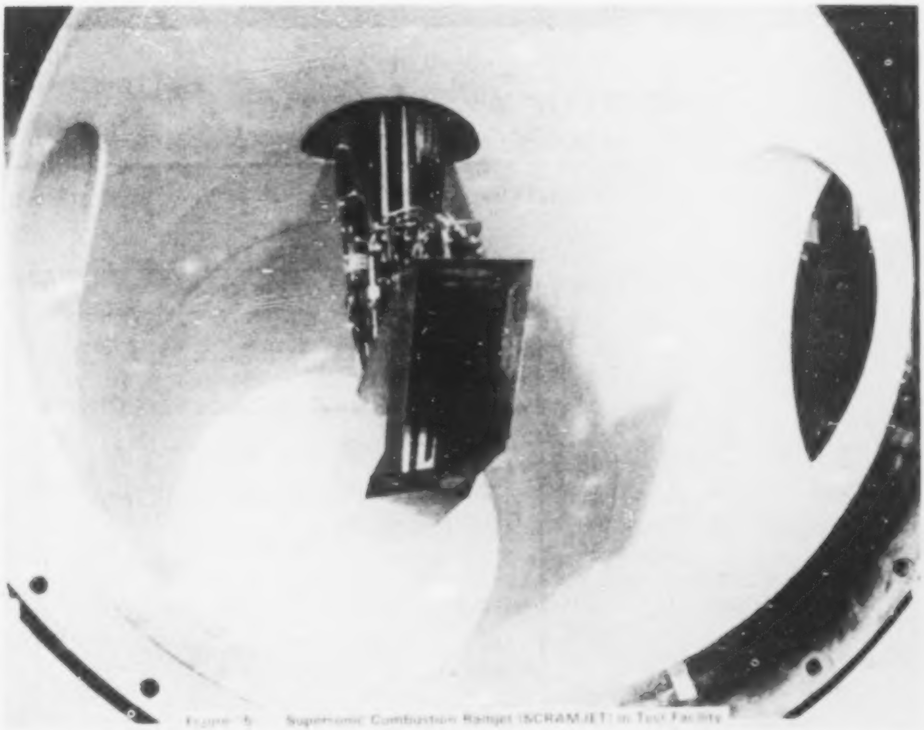


Figure 5: Supersonic Combustion Ramjet (SCRAMJET) in Test Facility

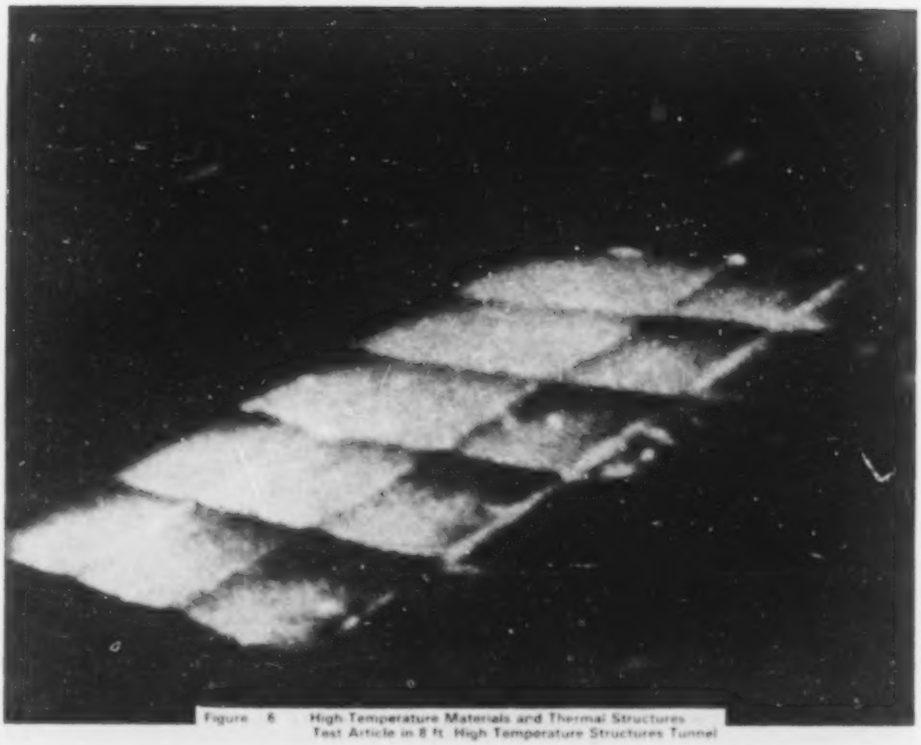


Figure 6 High Temperature Materials and Thermal Structures Test Article in 8 ft. High Temperature Structures Tunnel

Figure 7 Hypersonic Flight Research X 15 Airplane

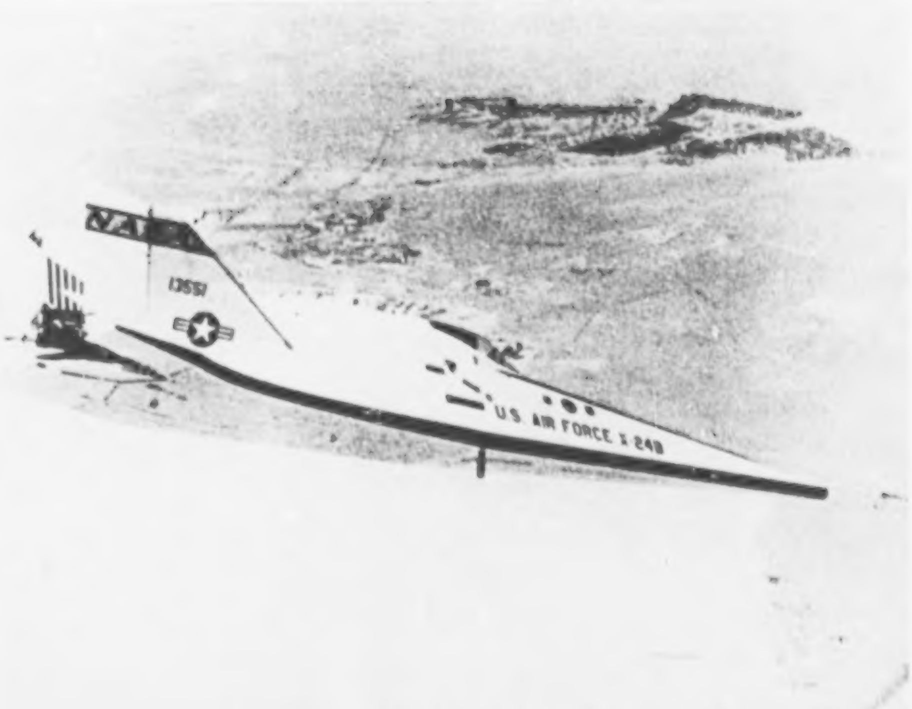

NASA
13551
U.S. AIR FORCE X 24B

Figure 8 Re-Entry Lifting Body Aerodynamics Background X-24

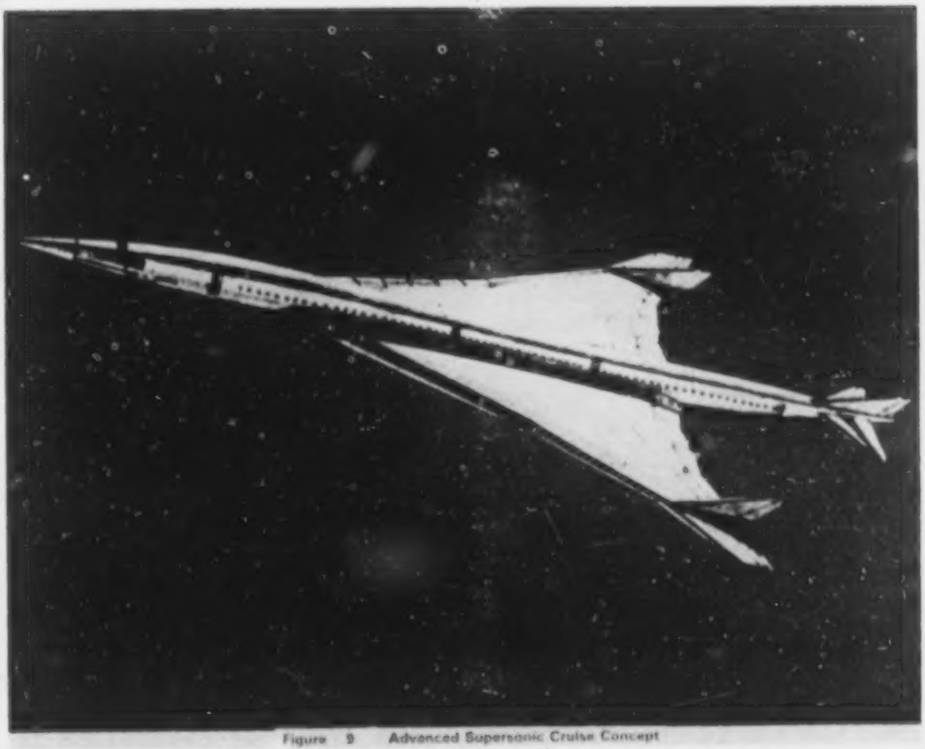


Figure 9 Advanced Supersonic Cruise Concept

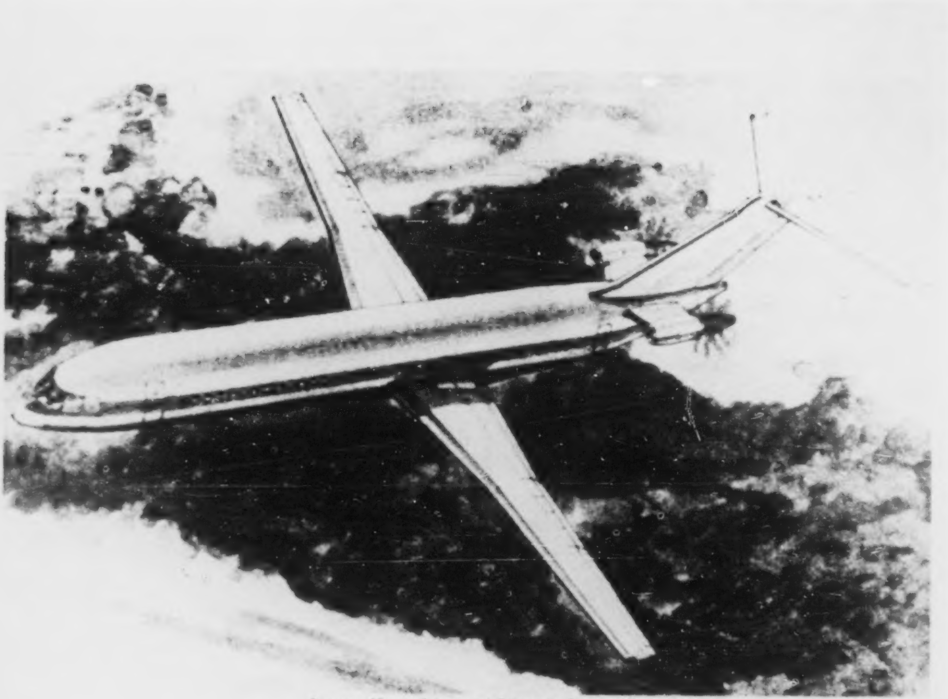


Figure 10 Advanced Subsonic Aircraft Concept

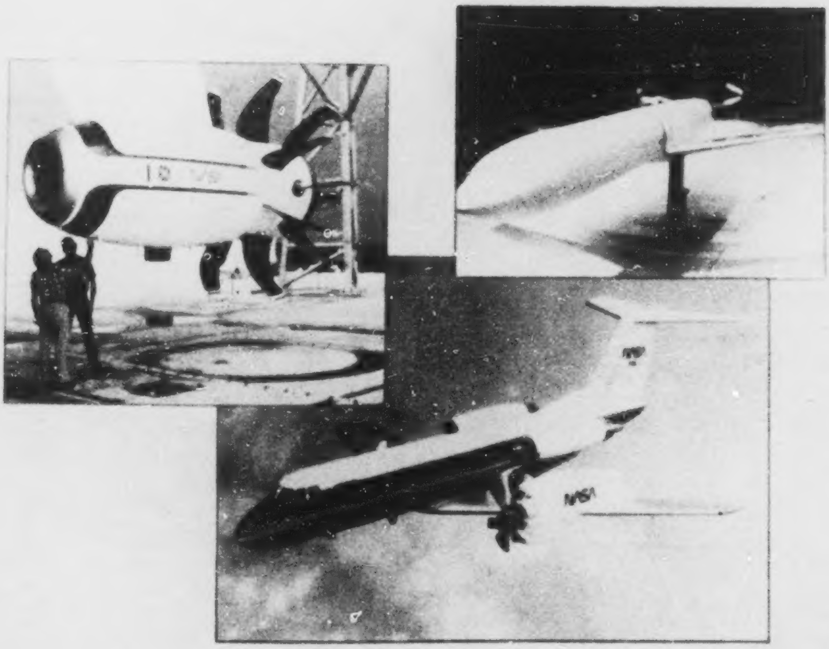


Figure 11 Advanced Turboprop Research

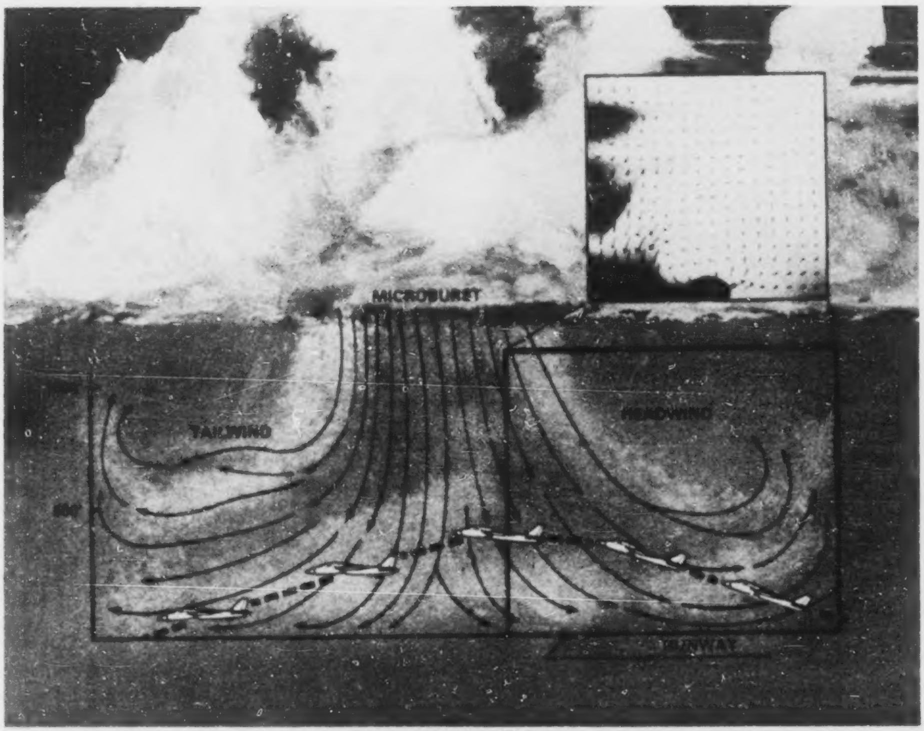

MICROBURST
TAILWIND
HEADWIND
RUNWAY

Figure 12 Wind Shear Modeling

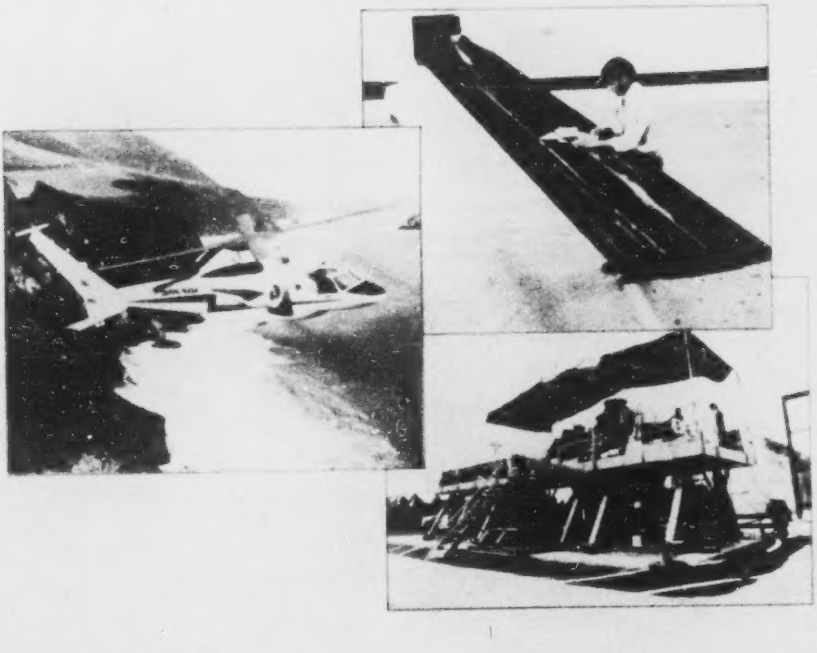


Figure 13 Rotor Systems Research Aircraft (RSRA) X Wing Concept

Figure 14 Numerical Aerodynamic Simulation (NAS) Program Picture of Cray 2 Computer

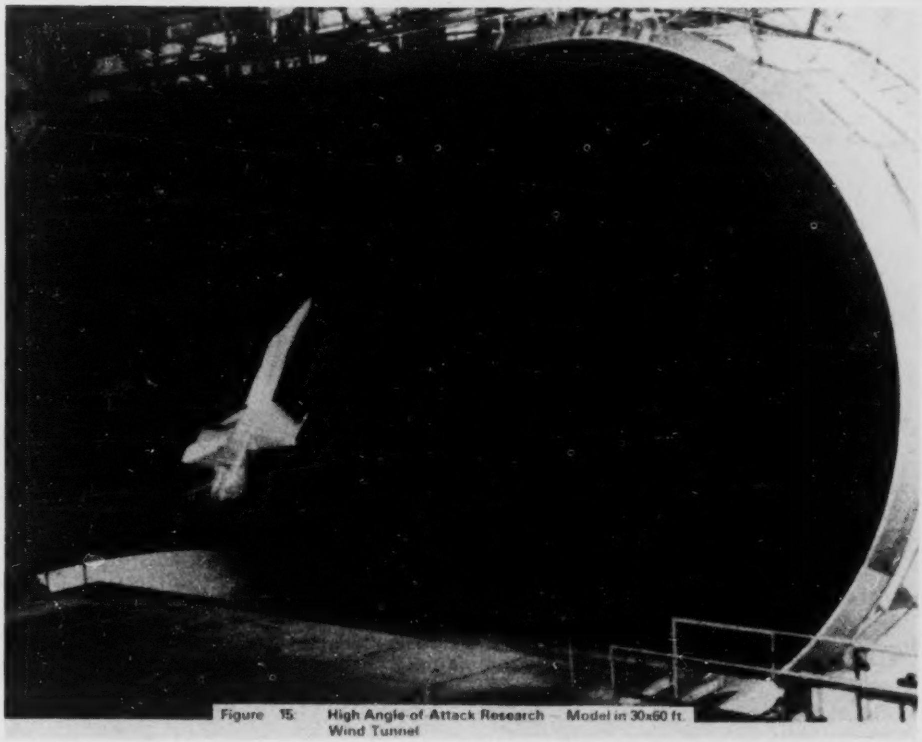


Figure 15 High Angle-of-Attack Research — Model in 30x60 ft. Wind Tunnel

QUESTIONS OF SENATOR GORTON AND THE ANSWERS THERETO

1. QUESTION - It is clear that DARPA and NASA are working toward the same objectives, even though each agency may have different perspectives on the program. Therefore, even though some of my questions to you may be similar to those I asked of Dr. Colladay, I am just as interested in DARPA's perspective on this program. In your opinion, what are the compelling reasons for initiating this program now, rather than later, particularly in light of the current budget environment?

ANSWER - By the year 2000, the technology of the SR-71 will be 40 years old. Shuttle technology will be about 30 years old, and the oldest shuttles will be nearing the end of their useful life. We will be pushing our acquisition and budgeting process to have replacements for these vehicles when we need them--even if we had started this program two or three years ago. Unfortunately, at that time, the enabling technology was not available; however, recent research in the areas of hypersonic air breathing propulsion; long-life, high temperature materials and structures; and computational aerodynamics has contributed to a consensus that an aerospace plane may be possible.

2. QUESTION - I am not asking you to divulge any classified information, but what are some of the potential military applications of this program?

ANSWER - We feel there are three classes of potential applications for the aerospace plane:

o As a space-launch vehicle capable of accelerating directly into orbit.

o Commercial applications.

o Numerous military applications, to include:

- New classes of long-range, very high speed, air defense missiles and cruise missiles.

- Long range interceptors with an extremely rapid response to any place on earth.

- A successor to the SR-71 high reconnaissance aircraft.

3. QUESTION

a. What does the relative distribution of funding -- NASA, 20% and DoD, 80% -- indicate?

ANSWER - There are currently five government organizations who are committing to this program--DARPA, NASA, SDIO, Navy, and Air Force--and the current method is to divide the budget accordingly. There are on-going negotiations internal to DoD to determine how DoD proportions the remaining 4/5 (or 80%) among the Defense participants.

b. Does this in any way reflect on the likely distribution of applications between the civil and military sectors?

ANSWER - No. The program has not progressed to the point that we can make budgetary assessments based solely on applications.

4. QUESTION

a. What can you tell us about the plans and progress that other nations have made in the hypersonic and transatmospheric flight regimes?

ANSWER - The British are building a device called HOTAL (horizontal take off and landing) and the Japanese are discussing a similar program. While the details are classified, there is indication that the Soviets have similar types of technologies available.

b. Do you believe that they have the same perspectives or expectations relative to potential applications as we do? If not, how do they differ?

ANSWER - As far as we know, both the British and the Japanese are looking at the development of commercial space-launch vehicles to compete with the U.S. shuttle and European Space Agency Ariene programs. In that regard, neither are as broadly based nor as technology intensive as the NASP program.

5. QUESTION

a. How long would the experimental flight research program likely last before a decision were made on the development of any operational vehicles?

ANSWER - Due to the complexity of the NASP, several years of flight tests will be required in order to understand the nature of the problems we expect to encounter. As a comparison, the X-29 forward-swept wing has undergone two years of flight testing with additional tests planned by the Air Force.

b. What would determine the time at which the experimental program would be terminated?

ANSWER - The flight tests would continue until we gain an understanding of the nature of problems and develop solutions.

6. QUESTION -Is there now any way to predict the cost and length of time to develop an operational vehicle?

ANSWER - Unfortunately, there is no precise answer to the question. However, we are projecting that the first flight of a research-type aircraft will occur in the mid-1990's. Based on the time taken to develop similar types of vehicles after the first research flights were over, it could take another decade of research flight activities before the vehicle is operationally ready -- somewhere around 2000 to 2010.

We anticipate that it will require $600M to prove the viability of the research vehicle. The cost to actually build the research vehicles is estimated at $3.0B. It is our view that it is too early to estimate the cost of follow-on operational vehicles which are given a specific mission to perform.

7. QUESTION - What is your assessment of the likely impact that the upcoming NASA/DoD space transportation system study will have on the National Aerospace Plane Program?

ANSWER - We are waiting for the results of the study to become public. In the interim, we have briefed the Committee several times and have had a very constructive dialogue. We hope the Committee will support the NASP as one of the activities that should become part of the architecture recommendations.

8. QUESTION - According to your testimony, late in 1983, government and industry specialists were convened to examine, among other things, potential "show-stoppers" for this program. Are there now any "show-stoppers" that exist for this program?

ANSWER - The propulsion area has been identified as the most critical element of the program. We feel we have developed a program which will get these risks under control before we actually commit to a vehicle.

9. QUESTION - What is your assessment of the expertise and resources that industry has brought, and will bring, to this program?

ANSWER - The NASP cannot be successful without the expertise and resources of U.S. industry. Much of the work to date on the enabling technologies has been accomplished by private industry. Some of the work was government funded and some was accomplished using independent R&D funds.

10. QUESTION - One of the goals of the program is to avoid developing a vehicle that requires a standing army similar to that of the Shuttle. How will this issue be resolved?

ANSWER - The key to easing the logistical problem is single stage-to-orbit, horizontal take-off and landing. This would allow us to dispense with dedicated and single use vertical launch facilities, the use of booster rockets and ferry aircraft such as the modified 747 used to carry the Shuttle. Additionally, by using air-breathing propulsion, we eliminate the need for large quantities of liquid oxygen and the facilities needed to support its use.

11. QUESTION - Without divulging any classified information, what fundamental differences would exist between a military vehicle and a civil vehicle, in any particular Mach regime?

ANSWER - Although we would use similar propulsion techniques and similar operating regimes, at this point we visualize radically different aircraft for military and civil applications. For example:

o Military application as a successor to the SR-71 would require a payload consisting of electronic systems, a series of sensors, data links, and similar equipment.

o A civilian passenger aircraft would require life support systems in addition to flight control systems.

12. QUESTION - According to your testimony, one of the primary objectives of the Phase II contracts is the development of a risk assessment for technology development, cost, and schedule. Can you elaborate on this objective?

ANSWER - During the technology phase, we hope to demonstrate the critical components of a vehicle as close to full-scale as possible. For example, we plan to build a full-scale model of the propulsion section, to place that section into an operating environment which we would expect the vehicle to encounter during actual flight, and to show that we can build a propulsion section which gives us the thrust, temperatures and pressures at which we expect the device to work. If successful, we would place the propulsion section into an aircraft and expect the aircraft to operate.

13. QUESTION

a. What are some of the spin-off technologies that could evolve from this program?

ANSWER - The high temperature, high strength materials being developed under this program will apply to numerous other aircraft engines and will make significant improvements in their efficiency and operating range. The calculational capabilities will have direct application to a myriad of other civil and military problems.

b. What other programs or systems will this program enhance?

ANSWER - Any program or system which would perform better or cost less if lighter weight, higher strength materials were available will benefit from the NASP program. For example, some of our work might make light weight, gas turbine engines viable for automobiles. Our work in fuel cells might provide an efficient, non-hydrocarbon based source of electrical power for aircraft, space vehicles, and other applications.

QUESTIONS OF SENATOR RIEGLE AND THE ANSWERS THERETO

Hypersonic Transatmospheric Vehicle

Question 1: FY 1987 will be the first year that NASA will have a line-item in its budget for the hypersonic Transatmospheric Vehicle (TAV), a request for $45 million. Exactly what will that money go for during the next Fiscal Year?

Answer 1: In FY 1987, the Transatmospheric R&T budget line funding of $45M will be used to augment and accelerate the development of the critical technologies in the National Aerospace Plane (NASP) program through: (1) acquisition of wind tunnel models for subsonic, supersonic, and hypersonic propulsion tests and also for thermal structures tests, (2) acceleration of materials technology, and (3) validation of Computational Fluid Dynamics (CFD) and aerothermostructural application codes used for vehicle design. The funding distribution is approximately $15M for propulsion technology, $20M for materials and structures, $6M for computational fluid dynamics, and $4M for concept/systems analysis.

Question 2: The TAV is estimated to cost more than $3 billion through FY 1993, when a prototype vehicle is expected to be developed. What are the projected outyear estimates for NASA funding during each of these years?

Answer 2: The runout estimates for the NASA technology portion of the National Aerospace Plan program are as follows:

	R&D $, Millions								
	PHASE II			PHASE III					
	FY86	FY87	FY88	FY89	FY90	FY91	FY92	FY93	TOTAL
Total NASA	16	62	74	95	160	120	45	25	597
Ongoing R&T Base	(16)	(17)	(18)	(20)	(20)	(20)	(21)	(22)	(154)
Transatmospheric R&T	--	(45)	(56)	(50)	(34)	(22)	(--)	(--)	(207)
				* (25)	(106)	(78)	(24)	(3)	(236)

* Phase III, technology demonstration using an experimental flight research vehicle, is dependent on the outcome of a future year budget decision, thus the numbers represent only planning estimates.

To prove the feasibility of this revolutionary new vehicle concept, an experimental flight research vehicle will be required. It will not be a prototype operational vehicle, however.

Question 3: As you well know, FY 1987 is the first year in which the Deficit Reduction Act will take effect. New projects, especially those costing $3 billion, are often hard to justify in times of severe cutbacks. Why should we proceed now with development of the TAV, especially when its applications are uncertain and so long-term in nature?

Answer 3: First of all, we are not asking for a commitment to the full budget of $3 billion. The program has been phased with a decision point in 1989, so that the decision to proceed with the more costly experimental vehicle development phase can be based on the assessment of the key technologies addressed in this next phase: full scale engine tests; available lightweight, high strength materials and hot structures; verified design codes; and a preliminary design and performance estimate of the X-vehicle. The NASP program is structured to provide a validated aerospace plane technology base by the mid-1990's. If single-stage-to-orbit vehicles using airbreathing propulsion are to be realistically considered as an option for the next generation space shuttle, then the National Aerospace Plane technology program must be initiated now. The basic concept feasibility phase has been completed, and for the first time, we think the state of technology is such that a hypersonic orbital lifting vehicle is achievable. Not only do the goals of the program include routine, rapid and low-cost access to space, but also sustained hypersonic cruise in the atmosphere for civil and military aircraft. Finally, it should be noted that the U.S. is not the only country pursuing this revolutionary technology.

Question 4: It is my understanding that in addition to the $45 million line-item request for the TAV, your FY 1987 budget includes an additional $17 million in the Aeronautics and Space Research and Technology Base for hypersonic activities. Is that correct? How is that money different from the line-item request? What will this additional money fund?

Answer 4: The $17 million in the on-going Aeronautics and Space R&T Base programs is separate from the transatmospheric R&T request, but it represents an essential integral component of the overall transatmospheric/hypersonic research program. These funds will continue our historical emphasis on the hypersonic and transatmospheric technologies that have enabled, and are critical to the success of, the NASP program, including scramjet propulsion technology, advanced high-temperature materials and thermal structural concepts, and computational fluid dynamics capability. The additional Transatmospheric R&T funding will be used to accelerate the pace of the efforts in each of these areas in order to move out aggressively, consistent with the proposed NASP program needs.

Question 5: What is the timeframe for development of the first TAV?

Answer 5: The timeframe for development of the first operational vehicles based on the technology developed in the NASP program is the turn of the century. The potential applications, both civil/commercial and military, include a next-generation space transportation system that could provide rapid and lower cost access to space by 2000 - potentially by an order-of-magnitude or more, plus the capability for sustained hypersonic cruise in the atmosphere.

Question 6: If all goes successfully through the technology assessment phase and the development of the first research vehicle, when can we expect to see applications of the TAV? In particular, when would you realistically expect to see commercial applications?

Answer 6: Future applications, based on the technology developed in the NASP program, could be operational between 2000 and 2010. The most likely first applications are projected to be a next-generation space transportation system, as a follow-on to the Shuttle, or a military vehicle. A commercial vehicle, such as a hypersonic transport, is thought to be a further term application of these advanced technologies, consistent with historical precedent for advanced air transportation systems.

Question 7: This project is very early in the conceptual stages. What if certain technologies are not available or mature enough to make the decision to go ahead with development of the first vehicle? Is there room for technological slippages? What kind of contingency plans have been made?

Answer 7: Contingency is built into the Phase II program with the most challenging items prioritized for early emphasis, whether based on degree of required innovation or lead time for the effort - thereby, allowing early determination if a shift in direction is needed in a given technology. However, based on the progress made in the enabling technologies over the last decade, combined with the intensive NASP Concept Feasibility Study conducted during the past two years, we are confident, that there are no "showstoppers" and that sufficient progress will be made in the critical technologies during Phase II to proceed with the proposed program.

Question 8: How will the research funds requested for the TAV be spent among the three NASA research centers? (Ames in California, Lewis in Ohio, and Langley in Virginia)? Will any of these centers have the lead on this project? What will each center focus its research work on?

Answer 8: The amount and type of research work at each NASA Center will be determined by the special expertise of the Center's technologists and the unique capabilities of its experimental and computational facilities required for the NASP program. There is no designated lead Center for the program. The emphasis at Ames will be in computational and experimental aerodynamics and flight vehicle systems technology. At Langley, the primary efforts will include hypersonic propulsion, aerothermal structures, configuration aerodynamics, and systems analyses. At Lewis, the key technology areas will be the low speed-to-supersonic propulsion including the internal flow computations, propulsion system components, engine materials, and cryogenic systems.

Aeronautics Budget

Question 9: The 1985 report from the President's Office of Science and Technology Policy called for increased research work on three types of future aircraft; subsonic, supersonic, and hypersonic. The report said that while work should be done concurrently, the primary emphasis should be on subsonic improvements. Yet, NASA seems to have leapfrogged the other aircraft types, elevating hypersonic research to the top position. Can you justify why this has occurred?

Answer 9: The National Aeronautical R&D Goals clearly represent a challenge to the entire aeronautics community, calling on both public and private sectors to engage in a national effort toward achievement of these goals. When viewed from a national perspective, the primary aeronautics R&T emphasis is in the subsonic goal area. In this, regard, prior NASA investments (more than $900 million from FY 1977-1986) in the Aircraft Energy Efficiency (ACEE) Program, the Advanced Turboprop (ATP) Program and other subsonic transport technology development activities have matured many of the key technologies to the point where industry involvement now dominates. In fact, industry is now accelerating technology readiness for product application in the early 1990's.

NASA is maintaining a strong fundamental base program that is addressing long-term R&T in emerging technology areas that promise high payoffs for subsonic aircraft. In addition, large portions of the generic R&T effort also support these vehicle classes. The apparent reduction in support is a result of a scheduled phase down of the ATP system technology program. A related subsonic area, the NASA rotorcraft program, is increasing its emphasis on the key problems of noise and vibration that severely limit the usefulness of civil and military rotorcraft. The rotorcraft program is being augmented in FY 1987 to develop and verify accurate predictive methods for noise and vibrations, and to explore new concepts.

In the supersonic cruise goal, NASA is initiating system studies with the aerospace industry to identify the needs and the most promising concepts for advanced high speed transports and to address the technical trades for speed, size, range, and fuel type, as well as economic and environmental considerations in advance of increases in funding for the key technologies. In the interim, we are maintaining our ongoing R&T efforts in the area until the results of the studies are known.

Major advances in airbreathing propulsion technology, high temperature materials, and computational methods are enabling an entirely new class of aerospace vehicles that could reshape military and civil aviation by the turn of the century. Pioneering, high-risk technology developments such as the NASA/DOD National Aerospace Plane program are an appropriate and traditional role for NASA. With the national need and the potential for a revolutionary advance in air and space transportation at hand, we plan to move aggressively in this area while maintaining a strong fundamental program addressing subsonic needs.

Question 10: The Advanced Turboprop Program will reach its culmination in FY 1987 with the flight test of the single-rotation engine. What activities does NASA plan to follow-up that flight-test with? Will the industry have sufficient knowledge with respect to acoustics and structural integrity to carry this new technology to an operational status? Is it sufficient to rely on other, non-governmental flight programs being done by Boeing, Douglas and Lockheed?

Answer 10: The flight test of the single-rotation turboprop will provide the fundamental scaling information needed for structures and acoustics. The continuing supporting research and technology, after the completion of the flight test, will emphasize propeller source acoustics, cabin environment, installation aerodynamics and counter-rotation performance. Although we are eliminating treated cabin acoustics from the flight test program, NASA will continue to develop a fundamental cabin environment technology base. This will include contracts with industry for development of analytical approaches that describe the cabin environment of turboprop powered aircraft and make use of the experimental data available from the industry-sponsored flight tests for code verification.

Completion of the NASA flight test of the single-rotation turboprop is necessary to complete the fundamental technology base in acoustics and structures that provides the foundation for development of future turboprop propulsion systems whether they be single- or counter-rotation. At this point in time, the industry is also aggressively moving to accelerate the technology necessary for product development in the early 1990's. The planned industry flight programs will provide valuable large-scale data for aeroelastics, source noise, cabin environment and installation aerodynamics. This data will be useful in verification of advanced analytical codes to be developed as part of NASA's supporting research and technology as well as providing configuration specific design information for industry. NASA will continue our traditional role in support of fundamental research and technology in the area of subsonic propulsion. We believe that the national effort, which includes the flight test programs and NASA's continuing fundamental research in advanced propellers, will provide the analytical and experimental technology base necessary for U.S. industry to develop turboprop-powered aircraft in the future.

Question 11: What is the status of the oblique-wing project, which is being conducted jointly with the Navy? What activities will occur in FY 1987 related to this project?

Answer 11: The program is being carried out in four phases. A feasibility study which showed concept viability has already been completed. The preliminary design phase is now underway with Rockwell International and should be completed this year. It is providing the general size and configuration of an aeroelastically tailored composite oblique wing and corresponding pivot assembly, and is also developing necessary details for incorporating the wing onto the NASA F-8 Digital Fly-By-Wire aircraft. A contract award is planned in FY 1987 for the detailed design work, fabrication and aircraft modification, and ground and flight qualification testing. The flight research program will be initiated in 1990.

Senator GORTON. Dr. Duncan and Dr. Tegnelia.

STATEMENT OF DR. ROBERT DUNCAN, DIRECTOR, DEFENSE ADVANCED RESEARCH PROJECTS AGENCY, ACCOMPANIED BY DR. JAMES A. TEGNELIA, DEPUTY DIRECTOR

Dr. DUNCAN. Good morning, Mr. Chairman. I would like to introduce Dr. Jim Tegnelia, the Deputy Director of DARPA. Originally when this hearing was set up, I had a conflict of having to appear before the House Appropriations Committee and I had asked Dr. Tegnelia to represent me at this hearing.

That particular conflict has been slipped, first into the afternoon, and now I understand it may be tomorrow. And so I came myself to be here, because I want to emphasize the necessary and crucial role that I believe NASA plays to the success of this program.

Senator GORTON. Thank you. We are happy to have both of you here. Please proceed.

[Slides shown during oral presentation.]

Dr. TEGNELIA. What I would like to do, sir, is take about 10 minutes or so and give you five charts on an overview of the defense view of the national aerospace plane. I would like to start out with one chart which shows you the view of the potential applications that might evolve from the technology that we are trying to demonstrate here.

As you can see, they are broken up into three classes of potential applications. The first one is a space launch system, a successor to the shuttle, a follow-on to the shuttle, as Dr. Colladay mentioned, with an objective of trying to reduce the cost, to routinize space operations.

I think, as you can imagine, our Strategic Defense Initiative Office is very interested in having this type of a capability in order to be able to support its operations. But also, commercial applications for that plane might also be envisioned.

The second type of application that we are interested in is the idea of commercial transport, commercial passenger service, probably the highest risk of the application. But certainly the technology, the fact that it could be serviced from conventional runways, be capable of horizontal takeoff and landing, use routinized fuel operations, and be a totally reuseable structure, would make those types of applications viable.

Now, to the Defense Department there are a whole series of applications associated with the defense posture that could evolve from this technology. To give you some ideas, a successor to our SR-71 high reconnaissance aircraft is one example. An interceptor aircraft, manned interceptor against other aircraft, can be envisioned. Successors to an advanced technology bomber, and even unmanned activities would evolve from this technology, such as very fast supersonic missile systems.

So this gives you a little bit of the overview, the fact that we do not think we are doing a single purpose technology program here, but really the fallout from this technology would in fact have multiple applications, both civil and military.

What I would like to do is give you a little bit of the idea of the operational environment of this aircraft. What I am plotting here is the Mach number, or the speed of the aircraft, and also the altitude of the aircraft. And as you can see from this chart, the SR-71 aircraft, the *Concorde* aircraft, really are in a fairly restricted operating envelope compared to what we envision for the national aerospace plane.

As an in-atmosphere vehicle, we would expect altitudes approaching 200,000 feet and Mach numbers approaching Mach 12 as the operating environment for this aircraft. And as a space vehicle, as you can see, above 350,000 feet, Mach 25, 26 would be envisioned.

The point to be made from this chart, the very simple message from this chart, is the fact that it is really a revolutionary departure from aircraft like the *Concorde*, aircraft like our set of existing commercial aircraft of today.

Now, this was already discussed by Dr. Colladay, but I would like to spend a little bit of time on the enabling technologies, to make only one very simple point to you, and that is these enabling technologies have just now become available to the aircraft industry as a whole, and it is now the availability of these technologies which determine the time at which one should envision undertaking such an initiative as we have here.

Fundamental to all of this, at least in my view, is the fact that we are now in the position of being able to build long-life structural materials that can operate above 3,000 degrees Fahrenheit. If you do not have this materials capability, you cannot build the fundamental fuselage elements and you cannot start to think about propulsion techniques which would permit you to operate at the high temperatures that are required to make this type of operation feasible at these atmospheric pressures, at these altitudes.

So the long-life materials are fundamental to this process. They are just now beginning to be demonstrated in any sufficient quantity and quality that we can expect to perform this activity, and they represent the enabler to make this type of an approach possible.

The fundamental issue, as Dr. Colladay mentioned, is the availability of this type of propulsion, propulsion that can operate at these types of altitudes, at very low atmospheric pressures, and still operate without having to carry their own oxygen.

And we are just now in the process of putting these types of things into tunnels and establishing that in fact we can get the thrusts that are required to be able to make this occur. So the airbreathing propulsion is the most critical element of the problem.

One other element is the fact that we just recently, with the advent of our supercomputers, have been able to make available the computational capability to do the calculations of a very difficult vehicular design. The integration of this design, the propulsion system and the fuselage system, is unprecedented in the way that we build current generation aircraft.

I am oversimplifying a little bit here, but generally, you can treat an aircraft design today as a separate engine development and a separate fuselage development, and then mate them at a later period. In this particular environment, what is necessary is to make sure that the propulsion device and the fuselage device are an integral package, that they are designed in order to be able to make sure that the aerodynamics of the fuselage are consistent with the aerodynamics of the propulsion.

That requires advanced computational capability, without which the national aerospace plane could not be possible. So these three enabling technologies—materials, computational capability, and propulsion—are just now coming online through the early eighties. They are just now enabling this technology, and now we are finally, we believe, able to undertake this type of initiative.

Now, what I would like to do for the last few minutes is to give you two charts on management.

The first chart has to do with a more detailed schedule than I care to get into here, but I really would like to make only one very simple point and that is, what we are now doing is embarking on the second phase of a three-phase program, the third phase of which builds the research vehicle for flight.

We are first of all trying to make sure that we can build the airframe components that we mentioned and integrate those with the engine or propulsion techniques, and show that we have the technology on board, before we commit to the research vehicle.

So we are very early into this process of trying to understand whether the technology is in fact viable, and our first phase—excuse me—our second phase of the program, which is about $600 million, and through most of the eighties requires us to demonstrate that full-scale with engine modules, with fuselage components, for instance tanks and the like, to show that the technology is on board before one actually commits the very large amounts of dollars that are necessary to be able to actually build the research vehicle.

So we are not asking you at this time to commit to the full-up vehicle. What we are asking you to do is to commit to the demonstration of the technology in a phased approach, to minimize the risk that we have before we commit to that vehicle.

I think the last chart that I would like to show you is one which again Dr. Colladay mentioned to you.

That is the fact that we really have a full team effort associated with this program, composed of three—the three essential components of our aerospace industry: First, the industrial component as a whole; second, the universities and research laboratories; and finally, the Government components.

I think you are aware of the fact that this national aerospace plane is a five agency or five component development activity. The components, as you know, are NASA, the Air Force, who has the overall lead responsibility for the program, the Defense Advanced Research Projects Agency [DARPA], an agency of the Office of the Secretary of Defense, has the lead in the technology phase of it, and also the U.S. Navy, as well as the SDIO office, are members in this.

And several of those representatives are here today. As you can see, the Air Force people who will lead this activity are in the audience today, and if you have any questions of them I'm sure they would be willing to answer them.

But in addition to these government people, you can see that the laboratory facilities, not only from NASA at Ames, Dryden, and Lewis, but also the Navy activities, to include their laboratories at

Johns Hopkins, have been integrally involved in this program as well.

And then finally, you can see that almost all of the major aerospace industry people have played a major role in this activity, have been players in this. We are now in the process of going through our source selection activity for the follow-on contracts for the technology parts of the program, and these people are now participating in that source selection activity. We expect to complete that probably by the end of this month.

So with that, Mr. Chairman, I am willing to undertake any questions. We think we have a very important program here.

I would like to make one point in closing, though, and that is we felt sufficient priority with regard to this program not to come in to you with—or to come into the Congress with a request for new money into the program. What we did in putting the program together was prioritize existing activities within our organizations, and in the process of doing this our organizations' total funding did not grow. And in fact, what we did was drop out lesser priority activities in order to be able to fund this program.

So we believe we are being responsible with regard to the tight budget conditions that we have today, by prioritizing and not asking for major increases in either the DARPA program, the Defense Department program as a whole, or the NASA program.

We think that is a responsible way to do that, and it is a show to you of our commitment to try to perform this program.

And with that, I will try to answer any questions you have.

Senator GORTON. Doctor, thank you very much. You have demonstrated once again that a picture is worth a thousand words.

And these questions can be answered by either of you or both of you. How long would the experimental flight research program—how long is it likely to last before a decision is made on the development of operational vehicles? And what will be a test of the transition of one to the other?

Dr. TEGNELIA. Generally, sir, we would expect that flight programs of this type would take several years to perform. We are just now completing the flight test of an X vehicle, the X-29 forward-swept wing.

And we have been in flight tests for that program for approximately 2 years, and we will continue to fly it. And so I think several years worth of flight tests would be adequate for us to understand the nature of the problem we have.

Senator GORTON. And essentially an understanding of the nature of the problem is the key to the movement from one phase to the other?

Dr. TEGNELIA. Yes, sir.

Senator GORTON. What is your assessment that the likely impact of the upcoming NASA-DOD space transportation system study will have on the national aerospace plane program?

Dr. TEGNELIA. Well, we are still waiting for the results of that study to become public. We have briefed that committee several times and we think we have had a very constructive dialog. We hope they will support this activity as one of the activities that should become part of the architecture recommendations that they come up with.

I personally think it is too early, though, to make a judgment as to what their recommendations are going to be.

Senator GORTON. According to your written testimony, late in 1983 Government and industry specialists met together to look at, among other things, potential show-stoppers, things which could lead you into a dead end.

What risks of just simply running into a dead end are there in this connection?

Dr. TEGNELIA. I think, consistent with Dr. Colladay's testimony this morning, what that committee really addressed was the fundamental issue for the viability of this concept: the propulsion area. And in fact, if you look at the breakout of our program—I might have shown you this—the technology that we emphasize the most in our next phase of the program is the propulsion activity.

That was emphasized the most in all of our previous work. It was identified by the group as the most critical element of the program, and we think we are investing in a way which is consistent to get those risks under control before we actually commit to a vehicle of this type.

Senator GORTON. Understanding that we are here in a nonsecured environment, I am not asking you for any classified information. Can you tell us, under those circumstances, what fundamental differences might exist between a military vehicle and a civil vehicle in connection with the studies you are conducting?

Dr. TEGNELIA. I guess the easiest way to answer that is it would depend upon the payloads you wanted to carry. In most of the commercial applications, the obvious commercial applications——

Senator GORTON. Would that be weight or bulk?

Dr. TEGNELIA. Well, for instance, if you are interested—let me take a very simple example to give you an idea. Let us assume we would like to take one military application as a successor to the SR-71, and the civilian application that you would try is you might consider it as a passenger aircraft.

Now, in the case of the passenger aircraft you have to be worried about life support systems, about the comfort and safety of the passengers and crew, whereas in the payload of an SR-71 follow-on you are talking about an electronics package, a series of sensors, data links, that type of thing.

And in that case the payload configuration, the way that you would actually design the aircraft to carry those two very different payload configurations, would determine how the two designs would differ. And while it is a little bit early to make the statement, I think it is fairly safe to say that those two designs would be very different aircraft.

Senator GORTON. Different speed?

Dr. TEGNELIA. No, sir, I think they would be in very similar operating regimes. But I think the vehicles themselves—for instance, if you have ever seen an SR-71 and compare that to, say, a passenger aircraft or a U-2 and compare it to a passenger aircraft, even though they may use similar types of propulsion techniques, they are radically different, radically different aircraft.

Senator GORTON. According to your testimony, one of the primary objectives of the phase 2 contract system is the development of a risk assessment for technology development costs, and schedules. Can you give us a little bit more detail in that connection?

Dr. TEGNELIA. Could you repeat that? I am not sure I quite understood your question.

Senator GORTON. Well, your objective in the whole set of contracts for phase 2 is the development of risk assessment for the technology development, for determining costs and, for firming up your schedule.

How are you going to go about doing that? What are those goals and how close do you think you are to them now?

Dr. TEGNELIA. Well, in a simple statement, what we are trying to do with the technology program is to demonstrate at as close to full-scale as we can the critical components of a vehicle, of a research vehicle or the next phase vehicle that we would like to fly.

And for example, what we would like to do is build a full-scale model of the propulsion section, which is the underside of this vehicle, and put that propulsion section into as close an operating environment as we expect the vehicle to encounter when it is actually flying, and show that we can build that propulsion section to get the thrust that we want to operate at, the temperatures that we want to operate at, and the pressures at which we expect that device to work.

And when we do that, then we would expect that we could put it onto the aircraft and expect the aircraft to operate. Until you do that, you have a fairly significant risk of how well you would expect the vehicle to perform.

Senator GORTON. So just as Dr. Colladay said, the real sensitive item is the propulsion system here. That is essentially the most difficult element of the process?

Dr. TEGNELIA. Yes, sir.

Senator GORTON. So you are fairly confident the model that we are looking at, what the outside of the proposed plane looks like, that that configuration is pretty good, but the propulsion system is still up in the air?

Dr. TEGNELIA. Well, I believe fundamentally that one of the other elements, as I showed you in that chart, one of the other elements that we're looking at is aircraft fuselage design. And we intend to build critical components of the aircraft fuselage as well, for instance, the hydrogen tank, and the leading edges of the device, which are going to encounter the highest temperatures that you would expect in flight. And we expect the combination of those to evolve the final fuselage configuration, and my judgment is this is our best estimate of it now, but it could change fairly drastically as we go through that phase 2 technology program.

Dr. DUNCAN. I might add something, if I could, to that, Mr. Chairman, something that I think is really unique about this system, is that the whole airplane plays a part in the propulsion system. It is an integrated airplane propulsion system like no other integration that is ever been done before.

The fore-part of the aircraft is a part of the compression stage of the engine and the after part of the aircraft is a part of the expansion stage of the engine. So one way that one could look at it, it is a flying engine in that sense.

And so Dr. Colladay emphasized the need for understanding airflow, the complex equations around the aircraft of this type and it is related to the integrated design and makes that an absolute must.

Fourth, and finally one of the reasons, at least, that there has been such an extended and wide support of our entire American venture in space has been the spinoff technologies and the kind of advantages that we find tangibly here on Earth in our daily lives.

Senator GORTON. What kind of spinoff technologies might well evolve from this program?

Dr. TEGNELIA. Well, I think there are some obvious ones: the materials that we mentioned to you, the high temperature and high-strength materials are fundamental to a large number of things we would do. For instance, you could take the materials that were being developed under this program and apply them to other aircraft engines and make significant improvements in their efficiency and also in their operating range, as well.

So the fact that one builds materials here that are going to play a role in other aircraft activities as well is one example. The calculational capability that we have here we are being forced into calculational capabilities for all of the reasons that Dr. Duncan said. But when we develop those capabilities, those also have applications to a myriad of other problems that we face, as well.

And so I think there will be a tremendous number of opportunities opened up by the technology that is associated here.

Senator GORTON. I have a number of other questions which I will submit to you in writing and other members may have some.

We have now been joined by Senator Gore.

If you have an opening statement, we would be glad to hear it or any questions you have.

Senator GORE. Thank you, Mr. Chairman. I will forgo an opening statement and I will keep my questions to a minimum because I did arrive late, and also I will ask your patience should I cover some ground that you undoubtedly have covered with the earlier panel.

Just to put it in layman's terms, I am interested in answers to the questions, "How long will it take?" and "How much will it cost?"

Dr. TEGNELIA. Well, my simple answer is that we expect from now to the next decade to be involved in building research aircraft. So the first flight of vehicles like this for research-type aircraft is the midnineties.

Senator GORE. The midnineties?

Dr. TEGNELIA. The midnineties for the research aircraft.

Senator GORE. For the operational aircraft?

Dr. TEGNELIA. There is a judgmental question associated with how long will it take you from the time that you begin your research flight activities until the time you have an operational vehicle ready to perform its function: for instance, the successor or follow-on to the shuttle.

Now, an estimate of what would be another 10 years. If you go back and find out how long it has taken us to develop similar types of vehicles after the first research flights were over, it is another decade or so. And so toward the year 2000 to 2010, that period of time is when you would expect to see operational vehicles of that type or of this type begin to surface. There are some questions with regard to cost which I could give you some feeling for and so much I cannot; I will be honest with you.

Our research activity, for the critical components that it is going to take to prove the viability of the research vehicle—the research flight vehicle—is $500 to $600 million.

Senator GORE. Now that is inclusive for the research vehicle?

Dr. TEGNELIA. That does not include the cost of actually building a flight for the research vehicle. The flight for the research vehicle is several billion dollars. And we are just now entering into that and I must tell you that our estimates of that cost will be refined as we go through this process. But they are really not all that accurately known at this time.

In my view, I think it is too early to estimate follow-on vehicles at this time. What I mean by "follow-on" is operational vehicles—vehicles which are given a specific mission to perform. I think the cost of that capability we really cannot estimate accurately at this time.

Senator GORE. But you would think it would take $500 to $700 million to get us up to the point in the midnineties where we are ready to build?

Dr. TEGNELIA. No, sir. Excuse me. It would take us about $3½, $2½, $3½ billion. The current estimate is $3.5 billion to do the technology and build the first flying vehicles. And that budget will get us into the midnineties, flying in the midnineties.

Now the first part of that investment to prove the critical technology is that half a billion—$500 million or $600 million that I mentioned to you would be the first—the upfront investment.

Senator GORE. Over what period of time?

Dr. TEGNELIA. Over 3 years.

Senator GORE. And then a decision will be made to go forward with the construction of a research vehicle?

Dr. TEGNELIA. Yes. If you do not mind, sir, maybe I will put up a chart that I was talking to toward the end.

This chart—this diamond here which occurs in the late 1980's is the decision which says, "I now have done enough technology; I know how the propulsion is going to work, I know how the airplane is to be designed. I built critical structural components and I am now ready to commit to a flight research vehicle." To get from where we are today to this diamond is a $600 million investment.

Dr. DUNCAN. Twenty percent of which would be NASA's, approximately.

Dr. TEGNELIA. And our requests to you now are for this $600 million investment. The decision to build the research vehicle still lies ahead of us. To go from here to the phase 3, which includes the flight of the research vehicle is a several billion dollar activity. The estimate now is $3 billion.

Senator GORE. Was the 80/20 split arrived at before or after the Budget Committee vote yesterday?

Dr. DUNCAN. Before.

Dr. TEGNELIA. Long before.

Senator GORE. Have you reevaluated now?

Let me proceed.

The total cost of the technology development and the manufacture of the research plane would then be $2 to $3 billion?

Dr. **Tegnelia**. Yes, sir.

Senator **Gore**. You would expect completion of the research plane and the beginning of testing in the mid-1990's?

Dr. **Tegnelia**. Yes, sir.

Senator **Gore**. At that point another decision point would be reached and it is simply too early to speculate about the cost of each one of these things?

Dr. **Tegnelia**. Yes, sir.

Senator **Gore**. It is also premature to talk about how many such a fleet might be composed of. But the military civilian breakdown is another area that attracts my interest here. And I understand that the chairman has some questions about this before, but the 80/20 split is a reflection of the plane's mission or merely a budget strategy.

Dr. **Tegnelia**. Sir, I do not think it was really a very elegant decision that went into the 80/20 split. As I mentioned to you, there is a team of five organizations—Government organizations—who are committing to this program: the Air Force, Navy, Strategic Defense Initiative Office, DARPA, for the Office of the Secretary of Defense and NASA and the first order cut at the budget was to divide it equally in fifths.

We, inside of the Department of the Defense, are in the process now of negotiating how we share our part of that five split. But basically NASA's budget was determined by dividing equally in five parts. And the reason for that is that the applications—the output from this type of device, are so imprecise at this this that there is no rational way to say, "Well, you are going to get 90 percent of the benefits of this vehicle, so you ought to pick up 90 percent of the cost." We do not know enough to do that type of an assessment yet.

So we simply divided it into five parts and we are now trying to apportion that cost fairly among the participants.

Senator **Gore**. Is there any indication of what other countries are interested in a project like this? Do you know of any indications that the Japanese——

Dr. **Tegnelia**. Well, the Japanese are talking about a program; the British are building a device called HOTAL; the horizontal takeoff and landing. And we have some understanding that we cannot talk about here, that the Soviets have similar types of technologies and might be doing similar things.

Senator **Gore**. To what extent does the supercomputer capacity technology create a chokepoint on a project like that?

Dr. **Tegnelia**. Well, it is an important prerequisite for doing this program for the reasons that Dr. Duncan mentioned. The fact is that it really is an integrated propulsion and fuselage capability, and you must be able to do the airflow calculations for that device before you start.

But we think we have the computational capability in hand today and we have, in fact, started to do those calculations to show we have that computational capability. So we think it is not a show-stopper.

Senator **Gore**. I understand that. But might it be for the Soviets?

Dr. **Tegnelia**. Yes, sir.

Senator **Gore**. Well, let me just summarize my time briefly, Mr. Chairman. As one member of the subcommittee, I am extremely enthusiastic about this program. I think it is one that we should explore vigorously. Unfortunately, we have unprecedented budget constraints, as everyone in this room is well aware. But mark me down as an enthusiastic supporter of this program.

Senator **Gorton**. Thank you. Thank you very much, and thank you both. Your testimony has been enlightening and helpful. We appreciate having you here.

Dr. **Duncan**. Thank you, Mr. Chairman.

Dr. **Tegnelia**. Thank you.

[The statement follows:]

Statement of Dr. James A. Tegnelia, Deputy Director, Defense Advanced Research Projects Agency

Mr. Chairman, members of the committee, and staff, it is a pleasure for me to appear before this subcommittee to discuss the Defense Advanced Research Projects Agency's participation in the National Aerospace Plane Program (NASP). This is a joint DoD/NASA research program which could lead to an entirely new family of aerospace vehicles. Conceptually, a future Aerospace Plane would be able to operate as an airplane at hypersonic velocities (4000 to 8000 miles per hour) in the upper atmosphere, or as a space launch vehicle capable of accelerating directly into orbit.

BACKGROUND

In 1982, the first phase of the current program began with DARPA's investigations of scramjet missiles for application to the Navy Outer Air Battle problem. DARPA also began addressing other applications of scramjet technologies and, in particular, the possibility of a hydrogen fueled vehicle. A series of analyses were performed to determine the maximum speed potential of scramjets. These analyses were iterated throughout 1983, eventually revealing the potential for a single stage to orbit (Mach 25) vehicle. Late in 1983, a group of government and industry specialists, including NASA personnel, was convened to examine the concept and to address the question of 'show-stoppers.' NASA expertise and participation were requested due to their future space transportation system needs and the involvement of the Langley Research Center in the area of hydrogen fueled scramjets and Mach 6-12 vehicle concepts. The outcome of the two-day meeting was the preparation of an initial proposal for DARPA support of critical technologies.

In April through June 1984, DARPA committed $6 million to continue studies of the concept. A 'government technical team' was formed and the Air Force Aeronautical Systems Division agreed to act as contract agent. The government team at this point consisted of three members from NASA Langley, one Navy and three Air Force. Due to the promising initial results produced by the contractor efforts, industry was again approached and in the fall of 1984, airframe/engine companies established small technical teams to evaluate the government's national design. These efforts were initially unfunded. In March of 1985, a major three-day DARPA review was conducted with all government team members and industry. As a result of this review several additional small contracts were awarded.

The objective of these efforts was to assess the status of hypersonic air breathing propulsion, computational fluid dynamics, and long life, high temperature materials and structures. Based upon this work the consensus was reached that an aerospace plane might be possible. Greater knowledge of supersonic combustion phenomena, developments in high strength, lightweight materials, and the availability of supercomputers for engine/airframe design and integration are further examples of recent technological advance that support this consensus.

THE PROGRAM

Based upon the status of these critical technologies, DARPA, NASA, the Air Force, the Navy and the Strategic Defense Initiative Organization have joined forces to formulate and begin work on the National Aerospace Plane Program. The program is of mutual interest because of its potential to produce a hypersonic, global flight vehicle or a second generation space transportation system. It would be of major importance if it can significantly reduce payload to orbit transportation costs for both NASA and DoD. The dramatically reduced transit times on longhaul airplane routes might also have significant economic benefit, particularly on trans-pacific flights. In Air Force Systems Command's Project Forecast II, we have just begun to explore the aerospace plane's military potential.

The concept centers on a liquid hydrogen-powered aero-space craft capable of horizontal takeoff and landing. The technology development phase or Phase II, which began this year, consists of maturation of key technologies and development of propulsion modules and airframe designs needed for an experimental flight research vehicles. Engine modules will be built and tested up to approximately March 8, the current practical limit of wind tunnels for engine tests. An experimental aircraft, or X-vehicle, will be designed to explore propulsion performance above March 8, while structures and materials needed to fabricate such a vehicle will be developed and tested. All program participants and others familiar with the program understand and agree that there is a significant degree of technical risk.

This Phase II technology development programs will culminate in a design for a NASP demonstrator which will validate the program goals; evaluate technology advances; fabricate and test critical hardware; and develop system components. During Phase III, the X-vehicle will be built and tested. The results of the NASP program will provide the civil industry, the Department of Defense and NASA, with an effective aerospace plan configuration based on technology sufficiently mature for development of operational systems.

While DARPA will lead the joint DoD-NASA technology effort for Phase II, the Air Force has been assigned overall DoD responsibility for the NASP research program and for Phase III. An internal DoD Memorandum of Agreement is currently being coordinated among the DoD participants, and we are working with NASA on a DoD-NASA Memorandum of Understanding concerning direction for this important program. Program offices for both DARPA and the Air Force will be staffed with Navy, Air Force, and NASA personnel.

There is approximately an 80%/20% funding split between DoD and NASA. The combined budgets of the DoD and NASA for the period through the end of FY 88 total about $600 million. Through Phase III, the current estimate is approximately $3 billion.

THE NASP

What might such an aero-space vehicle look like? This model is representative of several design concepts.

1. Highly intergrated engine and aircraft structure whereby the aircraft fuselage forebody is an integral part of the engine inlets and the aircraft fuselage afterbody is an integral part of the engine nozzles
2. Highly swept wing
3. High temperature metallic structure designed for many flights
4. Cooling of hot areas of nose and engine with heat pipes or fluid coolants
5. Large, highly streamlined fuselage with integral fuel tank
6. Multiple engines with multiple inlets and exhaust nozzles

We are currently in source selection for the major contracts for the Pase II efforts. The Phase II contracts have three primary objectives.

1. Definition of a NASP configuration which meets the program performance goals. The design shall be for a fully integrated configuration including cost, schedule, estimated risk, ground demonstration plan, and preliminary air vehicle specifications. The cost and performance estimates must be realistic and reproductible.
2. Design, fabrication, and testing of selected NASP subsystem/components.
3. Development of a risk assessment for technology development, cost and schedule.

The preferred research vehicle preliminary specification will be the primary product of Phase II. The specification and engine and other test data will be the primary technical inputs used to form the basis of Phase III of the NASP program. Phase III is envisioned to be a separate, competitive effort.

This concludes my formal statement. I am prepared to answer questions which you may have concerning the NASP or its applications. Thank you.

[The following information was subsequently received for the record:]

QUESTIONS OF SENATOR GORTON AND THE ANSWERS THERETO

1. QUESTION - It is clear that DARPA and NASA are working toward the same objectives, even though each agency may have different perspectives on the program. Therefore, even though some of my questions to you may be similar to those I asked of Dr. Colladay, I am just as interested in DARPA's perspective on this program. In your opinion, what are the compelling reasons for initiating this program now, rather than later, particularly in light of the current budget environment?

ANSWER - By the year 2000, the technology of the SR-71 will be 40 years old. Shuttle technology will be about 30 years old, and the oldest shuttles will be nearing the end of their useful life. We will be pushing our acquisition and budgeting process to have replacements for these vehicles when we need them--even if we had started this program two or three years ago. Unfortunately, at that time, the enabling technology was not available; however, recent research in the areas of hypersonic air breathing propulsion; long-life, high temperature materials and structures; and computational aerodynamics has contributed to a consensus that an aerospace plane may be possible.

2. QUESTION - I am not asking you to divulge any classified information, but what are some of the potential military applications of this program?

ANSWER - We feel there are three classes of potential applications for the aerospace plane:

- o As a space-launch vehicle capable of accelerating directly into orbit.
- o Commercial applications.
- o Numerous military applications, to include:
  - New classes of long-range, very high speed, air defense missiles and cruise missiles.
  - Long range interceptors with an extremely rapid response to any place on earth.
  - A successor to the SR-71 high reconnaissance aircraft.

3. QUESTION

a. What does the relative distribution of funding -- NASA, 20% and DoD, 80% -- indicate?

ANSWER - There are currently five government organizations who are committing to this program--DARPA, NASA, SDIO, Navy, and Air Force--and the current method is to divide the budget accordingly. There are on-going negotiations internal to DoD to determine how DoD proportions the remaining 4/5 (or 80%) among the Defense participants.

b. Does this in any way reflect on the likely distribution of applications between the civil and military sectors?

ANSWER - No. The program has not progressed to the point that we can make budgetary assessments based solely on applications.

4. QUESTION

a. What can you tell us about the plans and progress that other nations have made in the hypersonic and transatmospheric flight regimes?

ANSWER - The British are building a device called HOTAL (horizontal take off and landing) and the Japanese are discussing a similar program. While the details are classified, there is indication that the Soviets have similar types of technologies available.

b. Do you believe that they have the same perspectives or expectations relative to potential applications as we do? If not, how do they differ?

ANSWER - As far as we know, both the British and the Japanese are looking at the development of commercial space-launch vehicles to compete with the U.S. shuttle and European Space Agency Ariene programs. In that regard, neither are as broadly based nor as technology intensive as the NASP program.

5. QUESTION

a. How long would the experimental flight research program likely last before a decision were made on the development of any operational vehicles?

ANSWER - Due to the complexity of the NASP, several years of flight tests will be required in order to understand the nature of the problems we expect to encounter. As a comparison, the X-29 forward-swept wing has undergone two years of flight testing with additional tests planned by the Air Force.

b. What would determine the time at which the experimental program would be terminated?

ANSWER - The flight tests would continue until we gain an understanding of the nature of problems and develop solutions.

6. QUESTION -Is there now any way to predict the cost and length of time to develop an operational vehicle?

ANSWER - Unfortunately, there is no precise answer to the question. However, we are projecting that the first flight of a research-type aircraft will occur in the mid-1990's. Based on the time taken to develop similar types of vehicles after the first research flights were over, it could take another decade of research flight activities before the vehicle is operationally ready -- somewhere around 2000 to 2010.

We anticipate that it will require $600M to prove the viability of the research vehicle. The cost to actually build the research vehicles is estimated at $3.0B. It is our view that it is too early to estimate the cost of follow-on operational vehicles which are given a specific mission to perform.

7. QUESTION - What is your assessment of the likely impact that the upcoming NASA/DoD space transportation system study will have on the National Aerospace Plane Program?

ANSWER - We are waiting for the results of the study to become public. In the interim, we have briefed the Committee several times and have had a very constructive dialogue. We hope the Committee will support the NASP as one of the activities that should become part of the architecture recommendations.

8. QUESTION - According to your testimony, late in 1983, government and industry specialists were convened to examine, among other things, potential "show-stoppers" for this program. Are there now any "show-stoppers" that exist for this program?

ANSWER - The propulsion area has been identified as the most critical element of the program. We feel we have developed a program which will get these risks under control before we actually commit to a vehicle.

9. QUESTION - What is your assessment of the expertise and resources that industry has brought, and will bring, to this program?

ANSWER - The NASP cannot be successful without the expertise and resources of U.S. industry. Much of the work to date on the enabling technologies has been accomplished by private industry. Some of the work was government funded and some was accomplished using independent R&D funds.

10. QUESTION - One of the goals of the program is to avoid developing a vehicle that requires a standing army similar to that of the Shuttle. How will this issue be resolved?

ANSWER - The key to easing the logistical problem is single stage-to-orbit, horizontal take-off and landing. This would allow us to dispense with dedicated and single use vertical launch facilities, the use of booster rockets and ferry aircraft such as the modified 747 used to carry the Shuttle. Additionally, by using air-breathing propulsion, we eliminate the need for large quantities of liquid oxygen and the facilities needed to support its use.

11. QUESTION - Without divulging any classified information, what fundamental differences would exist between a military vehicle and a civil vehicle, in any particular Mach regime?

ANSWER - Although we would use similar propulsion techniques and similar operating regimes, at this point we visualize radically different aircraft for military and civil applications. For example:

o Military application as a successor to the SR-71 would require a payload consisting of electronic systems, a series of sensors, data links, and similar equipment.

o A civilian passenger aircraft would require life support systems in addition to flight control systems.

12. QUESTION - According to your testimony, one of the primary objectives of the Phase II contracts is the development of a risk assessment for technology development, cost, and schedule. Can you elaborate on this objective?

ANSWER - During the technology phase, we hope to demonstrate the critical components of a vehicle as close to full-scale as possible. For example, we plan to build a full-scale model of the propulsion section, to place that section into an operating environment which we would expect the vehicle to encounter during actual flight, and to show that we can build a propulsion section which gives us the thrust, temperatures and pressures at which we expect the device to work. If successful, we would place the propulsion section into an aircraft and expect the aircraft to operate.

13. QUESTION

a. What are some of the spin-off technologies that could evolve from this program?

ANSWER - The high temperature, high strength materials being developed under this program will apply to numerous other aircraft engines and will make significant improvements in their efficiency and operating range. The calculational capabilities will have direct application to a myriad of other civil and military problems.

b. What other programs or systems will this program enhance?

ANSWER - Any program or system which would perform better or cost less if lighter weight, higher strength materials were available will benefit from the NASP program. For example, some of our work might make light weight, gas turbine engines viable for automobiles. Our work in fuel cells might provide an efficient, non-hydrocarbon based source of electrical power for aircraft, space vehicles, and other applications.

QUESTIONS OF SENATOR RIEGLE AND THE ANSWERS THERETO

1. QUESTION - As you well know, FY 1987 is the first year in which the Deficit Reduction Act will take effect. New projects, especially those costing $3 billion, are often hard to justify in times of severe cutbacks. Why should we proceed now with development of the TAV, especially when its applications are uncertain and so long-term in nature?

ANSWER - By the end of this century, the current shuttle fleet will be nearing the end of its useful life, while our need for access to space will still be expanding. Given the usual 12-15 year length of our systems development process from concept to operation, it will take an ambitious program for us to be able to produce an aero-space plane in time to meet that turn-of-the century need date. While we would have liked to have begun the NASP several years ago, the technology was not yet mature enough to permit us to begin this program. Recent advances, however, in the areas of materials, propulsion and advanced analytic techniques using super computers now give us the confidence to begin. Therefore, one of the reasons for the current start date is a trade-off between the expected need date and technology availability and risk. The other reason has to do with the technology itself.

The technologies which make it possible for us to begin the NASP program also promise to revolutionize the entire aerospace industry. Other sectors of the economy will also benefit. Any program or system which would perform better or cost less if lighter weight, higher strength materials were available will benefit from the NASP program. For example, some of our work might make light weight, gas turbine engines viable for automobiles. Our work in fuel cells might provide an efficient source of electrical power for aircraft, space vehicles, and other applications. The high temperature, high strength materials being developed under this program will apply to numerous other aircraft engines and will make significant improvements in their efficiency and operating range. The calculational capabilities will have direct application to a myriad of other civil and military problems. We can't afford as a Nation not to begin the NASP.

2. QUESTION - I understand that in addition to DARPA, other Defense-related groups working on the TAV include the Navy, the Air Force, and the Strategic Defense Initiative Organization. Could you please tell us how each of these entities became involved and what each hopes to achieve from the development of a TAV?

ANSWER - During FY 1985 DARPA briefed each of these agencies (and the Army) on the status of its technology investigations into the feasibility of the NASP concept. The Air Force Defense Science Board was just completing a study of rocket powered launch systems and found the airbreathing potential shown by DARPA to be very promising and synergistic with the military need for basing flexibility, rapid response fast turn around and low cost to orbit. The Navy found that the concept offered an entirely new option for performing broad ocean area surveillance and space launch of satellites. The SDI organization determined that the potential for low launch cost and the general push of advanced materials and power system technology were highly complementary to SDI objectives. All parties joined with DARPA to establish the program as a truly 'grass roots' technological revolution, which eventually received endorsement by the Secretary of Defense. The level of benefit will be essentially the same for all of the program participants. We will all share in the knowledge and experience gained from a much needed research program that none of us individually could afford to undertake. Specifically, all agencies will be full partners in all aspects of the NASP Program. NASA, the Air Force, the Navy and the SDIO will each have a Deputy Program Manager in DARPA's Washington Program Office and the Air Force's Dayton program office who will be directly involved with the management of all program activities.

3. QUESTION - What contingencies do you have in case NASA's share of the funding is for the TAV is reduced or is stretched out?

ANSWER - The success of the NASP program is vitally dependent on the full participation of all five agencies. We need their combined funds, personnel and facilities to maximize the chances for a successful program. NASA's contribution is particularly important because of their long history of involvement with hypersonic technology and the Space Shuttle. Any reduction or stretch out of the NASA funds will significantly increase the risk to a program which all parties already acknowledge as a high risk program. Further, such action would also cause major perturbations in the NASP program schedule.

4. QUESTION - If all goes successfully through the technology assessment phase and the development of the first research vehicle, when can we expect to see applications of the TAV? In particular, when would you realistically expect to see commercial applications?

ANSWER - Obviously, the exact date at which applications of the NASP technology will become available cannot be predicted at this very early stage in the program. Congressional support of the funding as well as our technical progress will be major determinants of our schedule. It may be possible, however, to have operational versions of a NASP by the late 1990's. We expect that the first applications will be for DOD and NASA missions. Commercial applications will follow based on the experience and knowledge gained from the government operations. It is not unreasonable to expect that those commercial applications could appear within the first decade of the next century.

Senator **Gorton**. We now have a panel consisting of Dr. Krone, Mr. Schaufele, and Mr. Donahue. If they would come forward, we would appreciate it.

The chairman must leave at about 5 minutes of 11, and Senator Gore will carry on for a while. I will return. But I would like to hear something from each of you. If you could summarize your testimony in roughly 5 minutes each, it would be a big help. Your entire written remarks will be included in the record. Dr. Krone, you've got control. So you go first.

STATEMENT OF DR. NORRIS KRONE, CHAIRMAN, AIAA AD HOC ADVISORY COMMITTEE ON NATIONAL AERONAUTICS

Dr. **Krone**. Yes, sir. I plan longer than that, but I will talk fast. On behalf of the American Institute of Aeronautics and Astronautics, we appreciate the opportunity to come and express our views and possibly some of our concerns regarding the National Support of Aeronautics Research and Technology. In light of the projected estimate over the next 10 years, that aeronautics products market is something on the order of $535 billion, we think it is necessary to maintain strong support for aeronautical technology to produce the superior products of the future.

We see recognition of this in the OSTP National Aeronautical R&D Goals as published last year and we support all of those goals—all three: the subsonic, supersonic, as well as the hypersonic initiatives and particularly the revitalization strategy as described by their incentives for R&D activities in industry particularly the distinguishing of the procurement policies between R&D procurements and standard or production hardware procurements. We think there is a definite difference there and that is not distinguished well enough in the procurement regulations.

The key to the aerospace dominance as well as superiority of other advanced products is in the R&D investment that we are putting into it now.

We believe the NASA 1987 budget is insufficient to maintain across the board the kinds of initiatives for the goals that are stated. However, under the budget conditions that we have today, the $22 million increase in the R&D budget looks very nice and we totally support the $45 million in the NASA budget for the aerospace plane.

We recognize the aerospace plane as a revitalization of hypersonic technology that was in full swing between the midsixties and the midseventies and has been retarded, to a large degree, since then. As a matter of fact, however, there have been other technologies or associated technologies that bear upon the ability to build a successful aerospace plane that have come forward, including the supercomputers, the computational aerodynamics ability as well as the structural materials, the key—we would totally support the key technology for the aerospace plane as being the propulsion system itself.

NASA has shown that without question, the need to integrate the engine with the airframe. It is an absolute necessity in this case and the high-temperature materials and structural technology that has come along, and will be proven during the next phase of the program, is extremely important.

We do have one concern that is with regards to the technology and particularly the facilities available to do the testing. This vehicle will have to fly into flight regimes, and at speeds and mach numbers that are essentially untestable—in combination—in the ground facilities we have.

Consequently, we have to rely on the computational methods and the validation of those computational methods are going to be the key to the design of a successful aircraft.

With regards to the shuttle and particularly unfortunate accident regarding the *Challenger,* we think that the shuttle decisions and our near-term program for getting payloads into space should be uncoupled from the aerospace plane which is a long-term objective. We have got a lot of time between now and the time an operational vehicle will fly.

The management of the aerospace plane project, we think, offers an opportunity for unprecedented cooperation between the various agencies. Activities like this have not always been successful, but we think the enthusiasm that has been shown for this program make it possible. In this case the memorandums of agreement are being worked out now, and therefore, we think it is too early to realisticly assess how successful the management will be. We do have great confidence.

We have also recommended four areas for increasing and strengthening the NASA budget, including the verification of the computational methods, which is most important. The hot section turbine engine work which incidentally propulsionwise will be our bread and butter for the next 10 to 15 years, structural components, advanced composites and rotocraft technology which we think could be strengthened.

In summary, I would like to say that we support the aerospace plan project; we think that the supersonic and subsonic activities could be strengthened.

Thank you.

[The statement follows:]

Statement of Dr. Norris J. Krone, Chairman, Ad Hoc Advisory Committee on National Aeronautics, American Institute of Aeronautics and Astronautics

NATIONAL COMMITMENT TO AERONAUTICS

For the last few years the AIAA has been expressing profound concern regarding the Government's commitment to maintaining the U.S. as the dominant country in the field of aeronautics. Although the Government resources allocated to the development of aeronautical technology have been considerable it has been our position that the resource levels allocated to NASA were not commensurate with either the enormous free world aeronautics product market of the future, estimated to be approximately $535 billion dollars over the next ten years, or to maintain a strong lead in the critical military aircraft performance arena.

This situation continues to exist; however, we are pleased that there seems to be an increasing recognition of the problem. The "National Aeronautical R&D Goals" published in March 1985 by the Office of Science and Technology Policy (OSTP) is direct evidence of this, and we wholeheartedly endorse the stated goals and the accompanying revitalization strategy. The OSTP's recommendations for amendment of the Federal contracting and regulatory policy to distinguish between hardware and R&D procurements, for encouragement of cooperative efforts in technology developments and for the passage of Federal tax legislation to encourage private investment are three actions that may *partially* counter the increasing direct support being given to the foreign commercial aircraft industries by their governments.

The National security is also dependent on maintaining superior aerospace products; however, it should not be forgotten that the viability of the industrial base for military aerospace products is integrated to a large degree with the commercial base—they are mutually supportive. We need to examine procurement regulations to find ways to eliminate the time required to develop new weapon systems. The F-15 was originally conceived in approximately 1970. We have been studying an advanced tactical fighter since the mid-70s and have not yet started prototype development. The Soviet Union, on the other hand, has recently displayed three new fighter aircraft—the SU-27 Flanker, the MIG-29 Fulcrum and the MIG-31 Foxhound. The Foxhound is reported to be superior to any existing U.S. fighter aircraft!

The U.S. aerospace industry employs a large work force with huge total sales covering a wide variety of products including products of other industries (food, furniture, etc.), and enjoys a large favorable balance of trade in the world marketplace. There is no reason to believe the aerospace industry couldn't suffer the same fate as our ship building industry did after World War II if we don't work to maintain the technology advantage which is the key to superiority of future products, maintenance of the national security and leadership in world sales of aeronautical products. The degree of national security and the proportion of the world aeronautical products market that is captured in the future by the U.S. is *directly* related to the investment we make in today's aeronautical technology programs—there are tremendous dividends to be reaped in the future.

NASA FY 87 AERONAUTICS PROGRAM

General

Although the FY87 NASA aeronautics program reflects a growing recognition of the importance of aeronautical Research and Technology to the health of the country, we believe the 8.0% portion of the NASA budget devoted to aeronautical R&T is insufficient to maintain the U.S. as the dominant aeronautical country in the world. However, the $22M increase over the FY86 R&D Technology budget level plus the $45M programmed for the national aerospace plane does represent a step in the right direction.

The National Aerospace (NASP)

Hypersonic Technology.—Last year, Hypersonic technology was one of five areas we recommended for additional emphasis. We also recommended research programs directed at flight research vehicles to verify design parameters and correlate ground based (analytical and wind tunnel) predictions. Therefore we support the NASP program which represents the revitalization of the hypersonic flight regime research efforts that were in full stride between 1965 and 1975. A combination of factors including high fuel prices and the loss of interest in the high speed supersonic transport caused a retardation of hypersonic research in such disciplines as aerodynamics, scramjet propulsion systems, cryogenic cooling/thermal protection systems and vehicle system/sub-systems design and integration technologies—ones that are now being revived by the NSAP program. On the other hand, there are other technologies that have a direct bearing on our ability to build a practical aerospace plane that have been advancing rapidly during the last ten years—ones that have sparked the renewed interest in hypersonic aircraft. Included in these technologies are structural design techniques, high strength/temperature material sciences, avionics and advanced automated control design methodoloies, computer science hardware and software which enable us to solve complex flow field equations numerically, and techniques for handling large volumes of liquid hydrogen efficiently. We believe the technology has reached a point where the time is right to initiate actions directed at the definition of a hypersonic research vehicle.

The propulsion system is a critical key to the development of a useful aerospace plane. The Langley Research Center conducted a Hypersonics Research Engine (HRE) program that demonstrated the basic feasibility of building an engine that could operate at mach numbers greater than 5. It also led to the important conclusion that the only concept practical for a hypersonic airbreathing vehicle would require an integrated airframe/engine design. A scaled module of such a hydrogen burning propulsion unit was built and tested to Mach 7 at NSAS Langley. This effort laid the foundation for the propulsion concept; and therefore, the entire vehicle concept of the current aerospace plane program.

The ability to build a *practical* aerospace plane also depends heavily on reducing the structural weight of the vehicle. The enormous heat and temperature environment (both internal and external to the vehicle) presents a unique set of problems and challenges in addition to the ones normally existent for subsonic or superonic air vehicles. Recent advances in high temperature metals and metal matrix materials, advanced carbon-carbon, advance ceramics, structural designs for hydrogen regeneratively-cooled techniques and advanced insulated cryogenic tank designs have raised the expectations of reaching a vehicle structural weight threshold that will allow practical and economic hypersonic applications. The progress made during Phase II of the aerospace plane program should allow for a reasonable assessment of structural weights based on design configuration studies and material/structural data.

One major technical issue is the establishment of an adequate data base and overall validation of the design of the experimental manned transatmospheric research vehicle since the full scale vehicle cannot be ground tested through the full range of its operational flight speeds, Mach numbers and altitudes. A thorough evaluation of existing ground research facilities, their modernization and upgrading needs, the need for new ground facilities as well as possible flight research facility options must be established and the corresponding budget requirements defined. It is conceivable that if within the next two to three years sufficient progress has been made in Computational Fluid Dynamics, and if the methods are validated by realistic testing to a high degree of confidence, the need for extensive new ground and flight research facilities may not be too great. This facility evaluation is necessary in order to assure the ability to verify analytically determined design parameters associated with uncertainties such as the interaction between vehicle and engine flow, inlet region effects of forebody crossflow and viscous effects, inlet spillage flow effects with angle of attack variations, dynamic interactions between the engine operation and the vehicle motion, flight control dynamic responses to nozzle lift/thrust and pitching moment variation, etc. It is recommended that a substantial effort be conducted as soon as feasible to define the facility needs with a high level of realism.

Application.—Military vehicle effectiveness in generally measured by its ability to defeat a projected enemy threat. Commercial vehicle effectiveness is almost always measured by its ability to compete economically with other vehicles that can meet the projected need. Hypersonic air breathing vehicles have the potential to meet both military and commercial requirements; however, it is likely that the military benefits in the form of a high speed reconnaissance, attack or interception aircraft will initially be shown as viable applications. Single or first stage of a advanced Space Transportation System (STS) is also a potential early use of the technology. The hypersonic transport aircraft application must meet more stringent safety and economic (total operations) constraints and is therefore considered a longer term application which will probably depend upon the experience gained from earlier military or STS applications.

Effect of the Space Shuttle Challenger.—The AIAA membership shares the National grief following the loss of the Challenger and its flight crew. We are confident that when the facts are in and the analysis complete, the Shuttle program will go forward as a better and safer program. However, we believe it is important to remember that pushing the frontiers of aeronautics has always been and will continue to be accompanied with risk. As is the case for ordinary aircraft there is no such thing as 100% safety and when we are flying with vehicles designed to operate at extreme speeds, Mach numbers and altitudes the uncertainties are higher, the energy levels are enormous and the risks are also higher. This does not mean that we should not continuously strive towards and set as our goal 100% safety.

The nation's immediate, near and intermediate term need for a space transportation system (STS) should be totally uncoupled from the aerospace program. The space shuttle utilizes proven technology and it has completed an immense amount of testing which includes 24 successful flights. The aerospace plane is projected to be a more efficient STS; however, it must meet and overcome numerous technical challenges before it can be confidently substituted into the line up. The aerospace plane technology should be pursued as the key to our long term dominance in world aeronautics and the priority placed on it should be assigned in accordance with this goal.

Aerospace Plane Management.—There is a great deal enthusiasm among all agencies participating in the aerospace plane project. It is viewed by all as an exciting challenge; and therefore, there exists an opportunity to demonstrate unprecedented cooperation. The memoranda of agreements are currently being formulated and it is therefore too early to realistically judge how effectively the various agencies will interface or how the various agencies will divide the responsibility.

The flight vehicle planned for Phase III of the program should be based on solid technical progress made during Phase II of the program and not upon preconceived schedules. There should be no serious management problems during Phase III if the various organizations can agree on the Phase II program plan and specific requirements of the research vehicle.

National Aeronautical Goals

The goals established by OSTP in March 1985 specified objects in each of the three flight regimes—subsonic, supersonic and transatmospheric (hypersonic). The NASA support of the transatmospheric regime is clearly reflected in the FY87 program and as stated earlier we wholeheartedly support this increased emphasis. However we feel very strongly that the near term goals and specifically those programs associated with increased efficiency for subsonic and supersonic aircraft are woefully inadequate.

The technology required to reduce fuel consumption by a factor of two for subsonic aircraft is a realistic near term objective. One important key to accomplishing this would be the demonstration of practical techniques for maintaining laminar flow over the aircraft surface. Past efforts have shown the tremendous potential of laminar flow techniques; however, there is insufficient effort directed towards the development of integrating laminar flow techniques into the a practical aircraft design that includes low cost manufacturing and the reduction of day-to-day operating expenses. A flight demonstration of a practical laminar flow design is needed.

It is probable that there will be within 10 years an advanced operational transpacific supersonic transport with a range of five to six thousand miles and with ticket cost comparable with subsonic transports. A reduction from 10 to 3 or 4 hours flight time from the U.S. to the Pacific basin will open an enormous new market that we should not ignore. Also, efficient supersonic cruise has direct application to next generation military aircraft. Technologies that integrate to produce this capability include advanced material, propulsion and aerodynamic designs. NASA should increase its efforts directed at developing analytical capabilities that integrate the tools of various technology disciplines (structure, aerodynamic, etc.) into multi-disciplinary tools for producing realistic and optimized design options. Flight demonstrations to verify the new analytical capabilities are essential.

Technology Base Programs

The national aeronautical goals cannot be met without a strong and vigorous technology base program. Therefore, we strongly recommend the strengthening of the NASA program in the areas of: (1) verification and correlation of computational aerodynamics codes, (2) engine hot section technology for increasing engine life and reducing maintenance costs, (3) advanced structures and materials (metals and composites) and (4) rotorcraft technologies.

Verification of Computational Codes.—The ability to determine the characteristics and parameters of a complex flow field accurately has been greatly improved through the use of high speed computer simulation that uses numerical solution methods. Traditionally, analytical methods have been used in the initial design of air vehicle and propulsion systems but the final design has always required and has been the result of extensive wind tunnel and flight tests. With the development of advanced computational capability, significantly less hardware testing will be required; however, the computational tools are far from perfect and the code development must be accompanied by a vigorous and systematic program to provide comprehensive experimental verification and correlation of analytical predictions. Confidence in the codes can only be gained by a carefully structured verification program expanded to cover the full range of configurations and aerodynamic/thermodynamic phenomena to which the computational procedures are applied. It is important to realize that experimental verification is a vital element of the overall computational aerodynamics program, and it must receive at least equal emphasis to the development of the codes and computer facilities themselves. To do otherwise will result in less than desirable return on investment and could, if experimental verification is slighted, waste a portion of a vital national resource.

Turbine Engine Hot Section Technology.—Although great emphasis is being place don a propulsion system for the hypersonic flight vehicle it must not be forgotten that the "bread and butter" for aircraft propulsion for many years to come will be the gas turbine engine. The subsonic and supersonic national goals are dependent upon extending the life of the engine hot section components (by a factor of two) and reducing the maintenance cost of gas turbine engines. Starting in 1981 NASA did a commendable job in implementing the Hot Section Technology (HOST) program and as a result efforts to improve the understanding of the gas turbine hot section aerothermal environment and material structural responses are presently underway through a combination of contracts, grants and NASA in-house research activities. However, considerable additional work remains to be done in order to reap the potential benefits in this important key area for improving engine performance.

HOST developed hot section life prediction methods and life extension techniques are receiving broad application in the industry. Not only are these methods being used for their original turbofan application, they also are being used in advanced military engines as well as parts of the Space Shuttle Main Engine (SSME). Even broader application of the HOST developed concepts is possible. The NASP will require development and application of life prediction methods for a large portion of the vehicle as well as the propulsion system because of the generally hostile temperature environment brought about by the heating effects of high speed flight. In addition, the techniques developed under HOST should be extended to solve hot section problems in small size engines. NASA-Lewis has managed its internal HOST program very well and integrated the industry and academia participation in an effective manner. This very effective team should be retained in future years to pursue the aforementioned expansion of their work.

Advanced Structures and Composite Materials.—The reduction of structural weight by use of advanced composite materials is potentially the most important single technology needed for meeting the national aeronautics goals in all flight regimes. Application of advanced composites to primary structures of future subsonic transport aircraft is clearly necessary to maintain the U.S. competitive position in the international market and this position may be seriously jeopardized with the abandonment of the large structures programs.

Metal matrix composite materials consist of high strength fibers such as silicon carbide or boron, imbedded in a metal matrix (aluminum, titanium, etc.). The payoff of these materials is a substantial reduction in structural weight which has been verified by studies of large transport type aircraft that indicate a 35 percent reduction in structural weight when 33 percent of the structural material is metal matrix. This saving results from a complete resizing of the aircraft with lower associated engine power and reduced fuel requirements. Metal matrix materials development is being supported at a level well below that commensurate with its potential payoffs. Integrating the different materials, manufacturing techniques and maintaining structural integrity over many cycles of repeatable varying environments is the objective of these efforts.

Rotocraft Technologies.—The rotorcraft portion of this country's aerospace activity has probably been its most rapidly growing element in recent years. Capabilities of helicopters have improved very measurably and the numbers of aircraft used by both civil and military operators—approximately 40 percent of the military vehicles are rotorcraft—has grown substantially. The trend is continuing as more missions are identified and as lower operating costs bring rotorcraft within reach of more potential users.

Last year the AIAA stressed increased emphasis on rotorcraft R&D as one of its five specific recommendations. We are pleased to see the degree to which the 1987 budget has been able to move in that direction. Specifically, a focused program and goal for reduced noise and vibration has been established; this does address two high priority needs. The NASA National Rotorcraft Noise Reduction $(NR)^2$ program has been a unique, successful example of a new kind of R&D. Four contractors are being partially supported by NASA, partially by their own IR&D, and the combined efforts of the four plus NASA's in-house effort are being coordinated by NASA Langley, with a sharing of data among all parties. This approach appears to give maximum return on the taxpayer dollars and may well be an example that should be copied in other areas of basic research.

NASA has small programs in the technical areas of handling qualities (taking advantage of new digital avionics), economical deicing of rotors (for all-weather operations), low air speed systems, improved cockpits for unburdening the pilot, and efforts to predict rotor aerodynamics. Although these programs are in the right direction they need strengthening to keep pace with the foreign competition for the expanding helocraft market.

Conclusion

The AIAA strongly supports the national aeronautical goals and the renewed interest in the hypersonic regime as indicated in the NASA FY87 program. However, we believe the support of the near term subsonic and supersonic technologies are deficient and should be strengthened.

Senator GORTON. Mr. Schaufele.

STATEMENT OF ROGER D. SCHAUFELE, VICE PRESIDENT, ENGINEERING, DOUGLAS AIRCRAFT CO., McDONNELL DOUGLAS CORP.

Mr. SCHAUFELE. Mr. Chairman, I appreciate your invitation to testify at this hearing on NASA's fiscal year 1987 budget. I have submitted a written statement for the record that addresses all of the issues that you asked me to address and I would like to summarize the key points of that right now.

The National Aerospace Plane Program, we believe, holds the key to regaining a substantial lead in aerospace that was once enjoyed by the United States. As with most efforts having such potentially enormous benefits; however, it also contains some significant risks in achieving all of the vehicle and program goals. McDonnell Douglas shares the view that it is now time to move out with an aggressive program to develop the technologies and the research vehicles to reach for the goals of the National Aerospace Plane Program.

As you know, the program is aimed at the development and demonstration of the technology that will permit design, manufacture, and operation of aircraft capable of productive flight at hypersonic speeds and altitutes up to and including those required for exit-to and return-from Earth orbit. That such aircraft, applied to military missions, could contribute importantly to the defense of the United States.

The potential for high speeds in military applications, coupled with the flexibility of operations the aerospace plan provides, truly advance capabilities and potential roles of reconnaissance, defense, and strike. A military transport version of this vehicle could transport troops and critical supplies to trouble spots anywhere on Earth in a few hours. The aerospace plane will also provide assured, ready access to space, but before discussing the space applications, I would like first to discuss the potential commercial role for this vehicle.

Productivity anticipated by an aerospace plane in transporting passengers and cargo between distant city pairs leads to the envisioned commercial application. McDonnell Douglas Corp. has broadly defined a version of the aerospace plane for long-range commercial transport applications.

We focused on routes between the United States and the so-called Pacific-rim nations of the Far East on the desirable characteristics and viability of the so-called Orient Express. Distances from Washington, DC or New York to Tokyo and Beijing fall within a 6,500 nautical mile range. So does travel from Los Angeles or San Francisco to Hong Kong and Sidney. We picked 6,500 nautical miles as the range for our hypothetical Orient Express.

Based on the aerodynamics and thermodynamics of flight to and from orbit, there is a corridor of combinations of altitude and speed to support aerospace plane functional missions. Within this corridor there are regions identified with suitable fuels and engines for aerospace plane propulsion.

From a number of considerations, we have concluded that a mach 5 methane-powered version of the aerospace plane is the highest speed practical choice for a commercial Orient Express.

This transport is sized to carry a full load of 305 passengers and flies at 6,500 nautical miles in 2 hours and 25 minutes.

To an airline, the economic viability of such transports is a function of vehicle acquisition cost; of fuel, maintenance, and other operating costs; and the income from the fares. Although many of these costs are not yet known, the high speed of a mach 5 Orient Express assures unprecedented productivity and high income.

Preliminary calculations indicate one mach 5 aircraft might make four long-range flights per day compared with one flight for subsonic aircraft. Hence, its productivity potential is the basis for our current interest in the Orient Express.

As we have heard earlier, the national aerospace plane also has desirable characteristics such as providing assured, ready access to space. It achieves this characteristic by its autonomous aircraft-like operations from conventional runways.

An aerospace plane with these characteristics holds the promise of substantially lower costs to deliver payloads to space. A goal of one-tenth current costs has been established and some forecasts, as optimistic as one one-hundredth current costs have been made. Obviously, NASA, military, and commercial users would benefit from such lowered costs.

Serving as a transporter to and from the space station is a future role envisioned for the aerospace plane system. The flexibility and ready access to space characteristic of the aerospace plane allows it to respond to a number of potential missions.

The key technology devlopment areas necessary for the use of the aerospace plane are in a propulsion system and high-strength, high-temperature, and light-weight material, able to provide the performance and operational goals of the vehicle. Low structural weight and high thrust-minus-drag propulsion systems are vital to the success of the program. Much has been accomplished in the materials area and more is planned.

Several materials showing promise in the laboratory need further development effort before they can be classified as practical materials for aerospace applications. As an example, McDonnell Douglas Research Laboratory is developing rapid solidifcation rate powder metallurgy processes for producing high-termperature-resistant titanium alloys with reinforcements of boron.

The test results indicate that the specific strength of the rapid solidification technology titanium alloy at 1,400 degrees Fahrenheit is comparable to the room temperature strength of titanium alloys now be used. This alloy apears to be a potentially efficient external surface material for all but the hottest leading edge areas of the hypersonic Orient Express and will be usable over large areas of other aerospace plane configurations. Turnaround maintenance, now typical of the space shuttle protective tiles, would be eliminated by the use of this new alloy.

Propulsion system must operate over an extremely broad spectrum from zero speed to orbital velocity of about 25 times the speed of sound. This is an obvious technological challenge and one which cannot be verified over the entire speed range in the laboratory. Considerable progress has been made in computational predictions of aerodynamic and propulsion behavior and these techniques will be used, but actual verification of the performance above 8,000 to 10,000 feet per second will remain to be proven in flight.

Many other technical challenges exist, including: thermal management of the vehicle because of the heating encountered at high speed required for orbital insertion or during sustained high speed cruise flight in the upper atmosphere; extensive systems integration to achieve the required highly efficient configuration; and product assurance aspects of the vehicle necessary to the reliable operation and support of such an aerospace plane are also challenges. These and others require substantial effort but are not believed to require significant technology breakthroughs.

Technology development efforts in these key discipline areas are vital to the National aerospace plane Program and require validation through flight demonstration. This step is necessary to develop the confidence in the ability to integrate the key technologies in a viable operational vehicle.

In addition to the validation and demonstration aspects of a flight vehicle program, valuable insight into manufacturing and operational cost factors will also be obtained.

In summary, the National Aerospace Plane Program encompasses many areas of technical research and development that will benefit both the civil and military communities for many years to come. There are substantial challenges that must be met. However, with a properly structured development program we believe they can be overcome.

The National Aerospace Plane Program demonstration vehicle should prove the technical viability of the national aerospace plane for both civil and military applications. While such applications will then each require additional time and development effort, their ultimate achievement will be limited only by the need and the economics.

Thank you.

[The statement follows:]

STATEMENT OF ROGER D. SCHAUFELE, VICE PRESIDENT, ENGINEERING, DOUGLAS AIRCRAFT CO., MCDONNELL DOUGLAS CORP.

Mr. Chairman and members of the Subcommittee, I am Roger D. Schaufele, Vice President, Engineering at Douglas Aircraft Company, a component of the McDonnell Douglas Corporation.

I appreciate your invitation to testify at this hearing on the fiscal year 1987 budget for the National Aeronautics and Space Administration (NASA). I firmly believe that NASA's mission in both aeronautics and space research and development is critically important to the long-term progress and will being of our nation.

You have specifically asked me to discuss the Administration's new initiative, the National Aerospace Plane (NASP) Program, and to assess NASA and Administration plans and actions toward achievement of the National Aeronautical R&D Goals that were enunciated approximately a year ago by the White House Office of Science and Technology Policy.

THE "NATIONAL AEROSPACE PLANE" PROGRAM

The National Aerospace Plane Program holds the key to regaining the substantial lead in aerospace once enjoyed by the United States. As with most efforts having such potentially enormous benefits, it also contains significant risks in achieving all of the vehicle and program goals. There is little doubt that such a vehicle will be developed one day. McDonnell Douglas shares the view that it is now time to move out with an aggressive program to develop the technologies and the vehicle to reach for the goals of the National Aerospace Plane.

As you know, the NASP Program is aimed at development demonstration of the technology that will permit design, manufacture and operation of aircraft capable of productive flight at hypersonic speeds and altitudes up to and including those required for exit-to and return-from Earth orbit. That such aircraft, applied to military missions, could contribute importantly to the defense of the United States is self evident. The potential for such high speeds in military applications coupled with the flexibility of operations of the Aerospace Plane provides a system more difficult for our adversary to counter in the potential roles of reconnaissance, defense, and strike. A military transport version of this vehicle could transport troops and critical supplies to trouble spots anywhere on Earth in a few hours. The Aerospace Plane also provides assured, ready access to space, but before discussing the space applications, I would first like to discuss the potential commercial role of this vehicle.

Commercial Transport Applications of the Aerospace Plane

The productivity anticipated by an Aerospace Plane in transporting cargo and/or passengers between distant city pairs leads to the envisioned commercial application of the vehicle. The McDonnell Douglas Corporation has broadly defined a version of the Aerospace Plane for long-range commercial transport applications.

We focused on transportation of people and/or cargo between the United States and the so-called Pacific-rim nations of the Far East—hence, on the desirable characteristics and viability of a so-called "Orient Express". As seen in Figure 1, distances from Washington, D.C. or New York to Tokyo and Beijing fall within a 6,500 nautical mile range. So does travel from Los Angeles or San Francisco to Hong Kong and Sidney. Hence, 6,500 nautical miles was the range we chose for a hypothetical Orient Express.

Based on the aerodynamics and thermodynamics of flight to and from orbit, Figure 2 defines a corridor of combinations of altitude and speed below which the forces and temperatures on a vehicle exceed the capabilities of viable structural materials and above which aerodynamic lift forces are insufficient to support Aerospace Plane functional missions. Within this corridor are shown three regions identified with suitable fuels and engines for Aerospace Plane motive power. In particular, above Mach 6, only liquid hydrogen has sufficient energy per pound. Cryogenic hydrocarbons, like liquid methane (i.e., liquid natural gas), can be used below Mach 6 and conventional hydrocarbon fuels, like JP-4 (kerosene), can be used below Mach 3.5. Since, at Mach 5 cruise, the time for flight over the longest route in Figure 1 is only two hours and twenty minutes and the greater volume of liquid hydrogen leads to greater vehicle structural weight and cost as well as special storage considerations at commercial airports, we have concluded a Mach 5, methane-powered version of the Aerospace plane is the highest-speed, practical choice for a first commercial "Orient Express". This transport is depicted in Figure 3.

The Orient Express of Figure 3 is sized to carry a full load of 305 passengers in mixed-class seating. Figure 4 shows the location of the passenger compartment in this Mach 5 transport and Figure 5 is a cross-section through the passenger cabin consistent with 305 available seats.

As seen in Figure 6, passenger traffic to and from the Pacific-rim nations increased 2.5-times to 6.4 million passengers per year in the 9 year period from 1975 to 1984. The extrapolation in Figure 6, based on the same average annual rate of increase, indicates that traffic will exceed 30 million passengers per year by the year 2000. Since United States-to-Pacific-rim travel accounts for 41% of today's world-wide traffic on non-stop flights at distances of 4,500 nautical miles or more, we can expect the total world-wide traffic on such long range to exceed 60 million passengers per year by year 2000. However, because their high-speed results in high productivity, some 200 Mach 5, 305-passenger transports may be all that are required to service this large volume of traffic if they achieve an average 65% load factor.

To an airline, the economic viability of such transports is a function of vehicle acquisition cost; of fuel, maintenance, and other operating costs; and of the income from fares. Although many of these costs are not yet known, the high speed of a Mach 5 Orient Express assures unprecedented utilization and high income. Preliminary calculations indicate one Mach 5 aircraft might make four long range flights per day compared with one flight for subsonic aircraft. This productivity potential is the basis of our current interest in the Orient Express.

Clearly, comprehensive systems studies are needed to accurately project costs and income potential for different Orient Express candidates in order to confirm their economic viability and choose the prefered configuration. NASA has recognized this critical need and announced its intent to fund at least two such system studies. The

NASP demonstrator vehicle will also provide valuable information on Orient Express economic potential.

The civil applications potential of an Aerospace Plane will also depend critically on its environmental impact. Two environmental issues which affect public acceptance of high speed transports are their sonic boom at ground level and their effect on the ozone layer.

As shown in Figure 7, the ground level sonic boom pressure differential for a Mach 2.2 transport cruising at 65,000 feet is approximately two pounds per square foot (psf). While this is less than the Concorde sonic boom at cruise (2.5 psf), the ground-level sonic boom pressure differential from a Mach 5 transport cruising at almost 100,000 feet altitude would be less than 1.0 psi. This is low enough that public acceptance of overland flights is likely.

The effect of high-speed flight and the ozone layer around the earth is strongly a function of altitude. The Advanced Supersonic Transport (AST), as previously proposed, cruised at approximately 65,000 feet, an altitude at which the ozone layer may be vulnerable (Figure 7) because of the low quantity of atomic oxygen. When ozone has been depleted, atomic oxygen reacting with diatomic oxygen is required to restore the ozone level. The atomic oxygen at cruise altitudes suitable for the Mach 5 hypersonic transport (Figure 7) is sufficiently high to assure ozone level restoration and maintenance at a stable level after depletion as a result of fuel burning. In addition, methane and hydrogen are cleaner burning fuels than the JP-4 proposed for the AST.

Thus, both of these environmental issues are substantially less a problem with the Mach 5 transport than with vehicles that cruise slower and lower. A Mach 5 hypersonic transport cruising at 100,000 feet altitude may therefore gain public acceptance more easily than the previously considered AST.

On Space Operations

As I indicated earlier, the National Aerospace Plane also has the desirable characteristic of providing assured, ready access to space. It achieves this characteristic by its autonomous aircraft-like operations from conventional runways. It avoids the use of specialized launch and tracking facilities associated with today's space systems. It could be ready for take-off in any direction from major airport facilities to aid, support or otherwise service the space station. Because of the Aerospace Plane's aerodynamic performance at hypersonic speeds, it need not wait in orbit to return, but can land in the continental United States from lower earth orbits within one orbit.

An Aerospace Plane with these characteristics holds the promise of substantially lower costs to deliver payloads to space. A goal of $\frac{1}{10}$th current costs has been established and forecasts as low as $\frac{1}{100}$th current costs have been made. Obviously, NASA, military and commercial users would benefit from such lower costs. Serving as a transporter to and from the Space Station is a future role envisioned for the system. The flexibility and ready access to space characteristic of the Aerospace Plane allows it to respond quickly to unforeseen needs in space. For example, the Aerospace Plane might replace and/or retrieve a failed satellite; or, perhaps, perform the function of the failed satellite for a period of time until the satellite can be replaced. The potential goes on.

On Technology Readiness for NASP Development

Hypersonic and transatmospheric flight are not new ideas. There were extensive NASA and DOD-supported programs in the 1950's and 1960's aimed at various missions requiring hypersonic flight in the atmosphere by lifting vehicles. These programs included studies to define desirable system and subsystem characteristic and technology requirements as well as specific programs and efforts to develop the needed technologies and systems.

In the 1970's due to accelerating costs and the need to focus available resources on the Space Shuttle, efforts on other reusable space and hypersonic-cruise systems were terminated or limited to low-level technology efforts. These efforts continued however to make progress toward resolution of still-formidable technical challenges in the key technology areas of hypersonic air breathing propulsion, materials and structures, and aerothermodynamics and heat transfer. In parallel with such efforts, there has been significant progress in generic technologies applicable across the speed range and essential to hypersonic flight. These include digital flight guidance and control hardware and software, active controls, and interdisciplinary analysis and design methodology.

The key technology development areas necessary to the use of the Aerospace Plane are in high-strength, high-temperature and light-weight materials, and in a propulsion system able to provide the performance and operability goals of the vehicle. Low structural weight and a high thrust-minus-drag propulsion system are vital to the success of the program. Much as been accomplished in the materials area and more is planned. Several materials showing promise in the laboratory need further development effort before they can be classified as practical materials for aerospace applications. As an example, McDonnell Douglas Research Laboratory is developing rapid solidification rate (RSR) powder metallurgy processes for producing high-temperature-resistant titanium alloys with in-situ reinforcements of boron. The test results presented in Figure 8 indicate that the specific strength of the rapid solidification technology (RST) titanium alloy at 1400°F is comparable to the room temperature strength of titanium alloys now being used. This RST alloy appears to be a potentially efficient external surface material for all but the hottest leading edge reigns of the hypersonic Orient Express and will be usable over large areas of other aerospace plane configurations. Turn around maintenance, now typical of the Space Shuttle protective titles, would be eliminated by use of this new alloy.

The propulsion system must operate over an extremely broad spectrum from zero speed to orbital velocity (about 25 times the speed of sound). This is an obvious technological challenge and one which cannot be verified over the entire speed range in the laboratory. Considerable progress has been made in computational predictions of aerodynamic and propulsion behavior and these techniques will be used, but actual verification of performance above 8000 to 10,000 feet per second will remain to be proven in flight. Refurbishment of certain unique NASA facilities would permit extending the laboratory verification to about 16,000 feet per second.

Many other technical challenges exist, including: thermal management of the vehicle because of the heating encountered at high speed required for orbital insertion or during sustained high speed cruise flight in the upper atomosphere; extensive systems integration to achieve the required highly efficient configuration; and product assurance aspects of the vehicle necessary to the reliable operation and support of such an Aerospace Plane. These and others require substantial effort but are not believed to require significant technology break throughs.

Technology development efforts in these key discipline areas are vital to the National Aerospace Plane Program and require validation in a demonstration vehicle. This step is necessary to develop confidence in the ability to integrate the key disciplines in a viable operational vehicle. In addition to the validation and demonstration aspects of a flight vehicle program, valuable insight into manufacturing and operational cost factors will also be obtained.

In spite of current progress and the good work that has been done in past years related to hypersonic vehicles, much remains to be accomplished. Necessary test facilities need to be reactivated and expanded. Research must progress from the laboratory to the vehicle design and development stage. Technology efforts must also lead to reliability and durability of such subsystems and of engine, airframe, and tank structures to meet transport standards or military vehicle requirements.

On NASP Program Responsibilities

The Aerospace Plane has such broad potential capabilities that many government agencies will be interested and stand to benefit from its development. NASA and the various branches of DoD also have much to contribute to its development. While many government branches may be involved, and indeed, provide funding, it is believed essential that a streamlined organization with clear management responsibilities and lines of communication be formed to carry out such a complex and challenging program. Clearly NASA and DoD have unique roles in system definition and evaluation for civil and military applications. NASA and DoD involvement in Aerospace Plane technology development should be done in a way that takes maximum advantage of current staff and facilities.

Impact of the Space Shuttle Accident

The unfortunate accident of the Shuttle orbiter Challenger does not have a direct bearing on the National Aerospace Plane Program. The nation needs the shuttle program to carry on its currently defined mission in space. The National Aerospace Plane Program is the next logical step to provide less costly, more flexible space operations in earth orbit.

NATIONAL AERONAUTICAL R&D GOALS

The White House Office of Science and Technology Policy report of April 1985 comprehensively delineated specific national goals for aeronautics research and development in three areas—"Subsonics", "Supersonics", and "Transatmospherics". I will briefly address them in reverse order.

The Transatmospherics Goal: "To Secure Future Options" is well served by current administration plans and actions. The NASP Program aggressively addresses the required research and development activity to achieve this goal.

The Supersonics Goal: "To Attain Long-Distance Efficiency" is adequately addressed by the DoD for fighter and other military aircraft. The high-speed transport elements of this Goal are effectively addressed within the NASP program. For example, NASA NASP involvement includes appropriate evaluation of a supersonic transport as a candidate for Orient Express or other long-range transport missions.

Unfortunately, funding of reseach to achieve the Subsonics Goal: "To Build Trans-Century Renewal" was severely curtailed over a year ago, well before Gramm-Rudman, because the low level of NASA's R&D budget was not adequate to cover all three goals together with needed increases in R&T Base funding. Specifically, the Aircraft Energy Efficiency (ACEE) program to develop composites for large-aircraft wing and fuselage structure was cancelled in early 1985, and projected NASA budgets will not support adequate flight service evaluation of laminar flow control. Both of these technologies are critical to development of more efficient subsonic aircraft. Without their timely development, the U.S. risks the loss of major portions of the civil aircraft market which will continue to be dominated by subsonic aircraft into the next century.

SUMMARY

The National Aerospace Plane Program encompasses many areas of technical research and development that will benefit both the civil and military communities for many years to come. There are substantial challenges that must be met. However, with a properly structured development program we believe they can be overcome.

The NASP demonstration vehicle should prove the technical viability of the NASP for both civil and military applications. While such applications will then each require additional time and development effort, their ultimate achievement will be limited only by need and economics.

DISTANCES BETWEEN UNITED STATES AND PACIFIC-RIM GOVERNMENT AND COMMERCIAL CENTERS

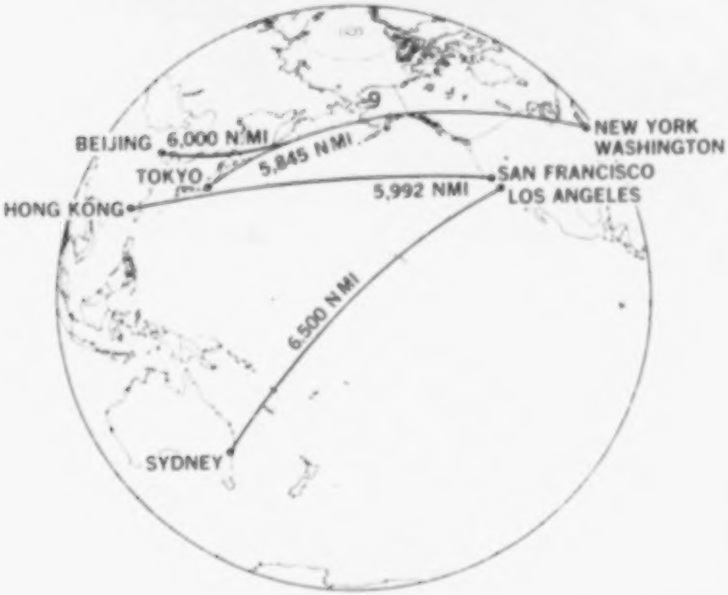

BEIJING
6,000 N.MI
TOKYO
5,845 NMI
HONG KONG
5,992 NMI
NEW YORK
WASHINGTON
SAN FRANCISCO
LOS ANGELES
6,500 NMI
SYDNEY

FIGURE 1.

AEROSPACE PLANE FLIGHT CORRIDOR AND SUITABLE ENGINES AND FUELS

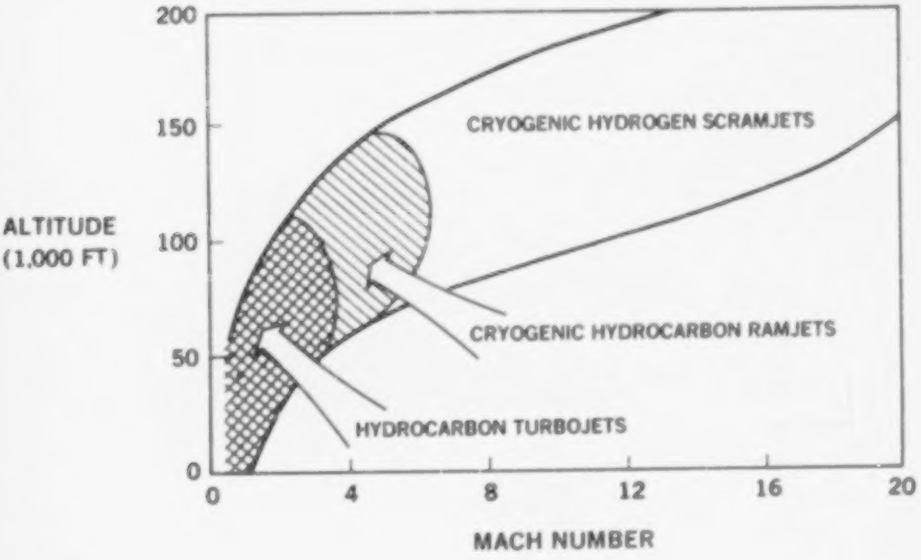
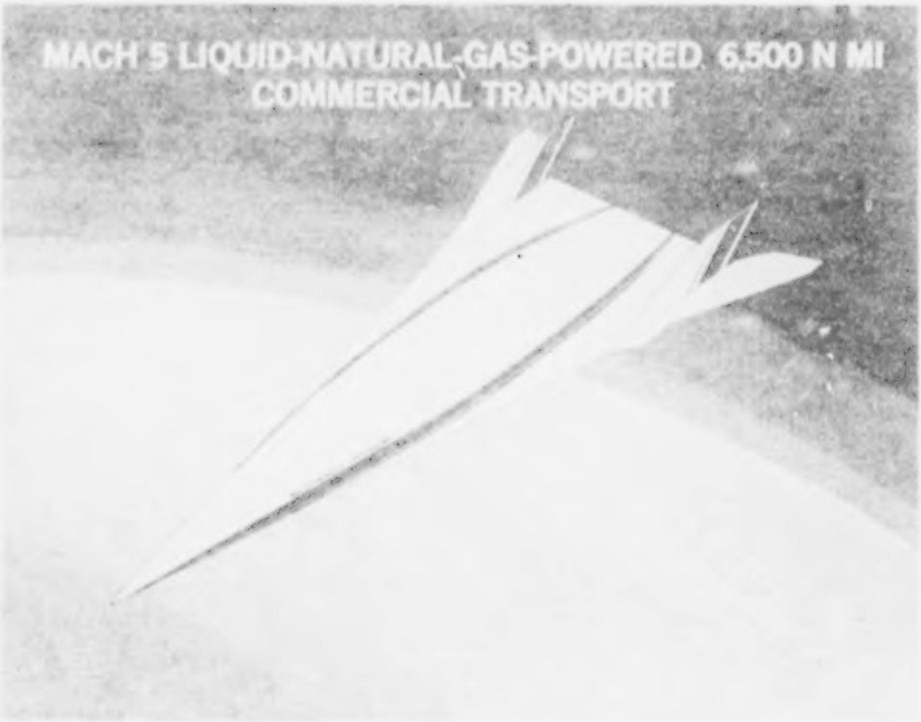


FIGURE 2.



MACH 5 LIQUID-NATURAL-GAS-POWERED 6,500 N MI COMMERCIAL TRANSPORT

LOCATION OF PASSENGER COMPARTMENT IN 305-PASSENGER, MACH 5 COMMERCIAL TRANSPORT

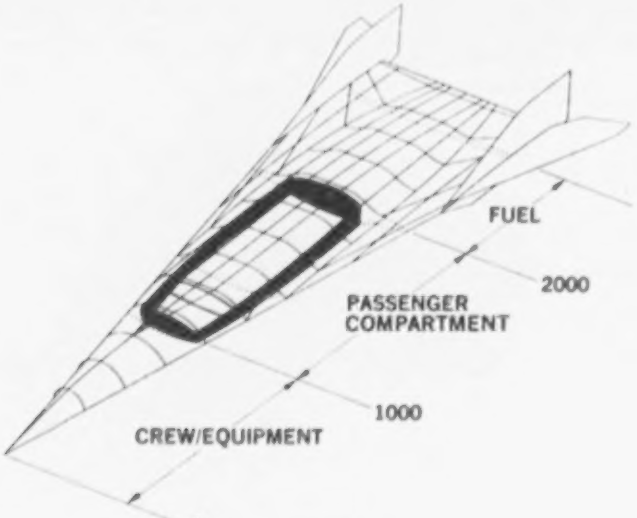

FUEL
2000
PASSENGER COMPARTMENT
1000
CREW/EQUIPMENT
0

FIGURE 4.

7

TYPICAL CROSS SECTION OF THE PASSENGER COMPARTMENT OF A COMMERCIAL 305-PASSENGER, MACH 5 TRANSPORT

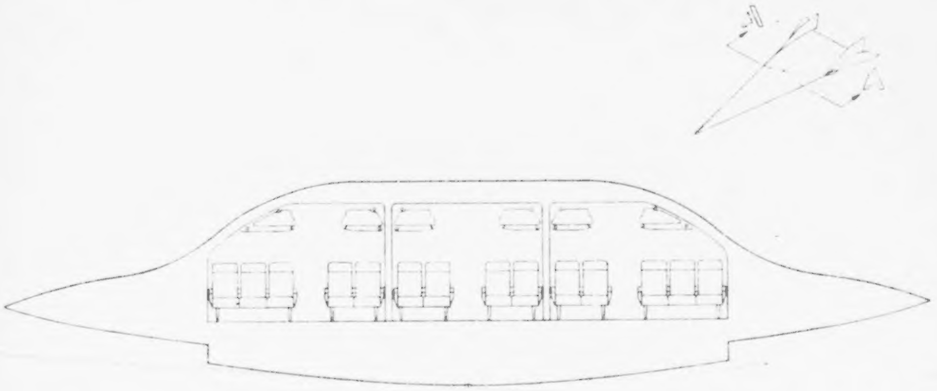


FIGURE 5.

RECENT AND PROJECTED GROWTH OF PASSENGER TRAFFIC BETWEEN THE UNITED STATES AND PACIFIC-RIM NATIONS

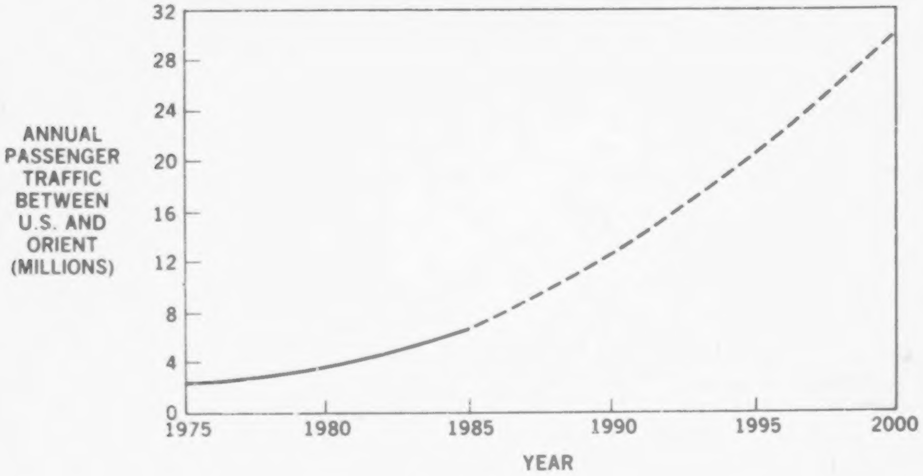


FIGURE 6

EFFECT OF ALTITUDE AND SPEED ON ENVIRONMENTAL CONCERNS

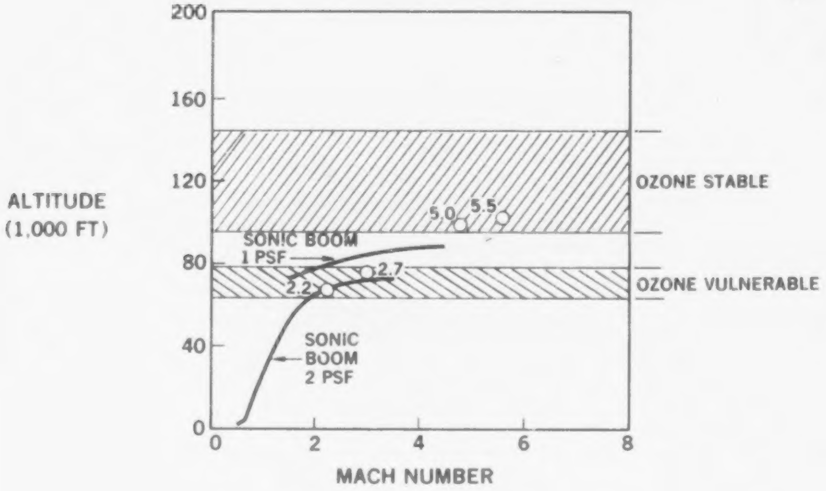


FIGURE 7.

RAPID SOLIDIFICATION TECHNOLOGY (RST) TITANIUM ALLOY FOR HIGH TEMPERATURE APPLICATIONS

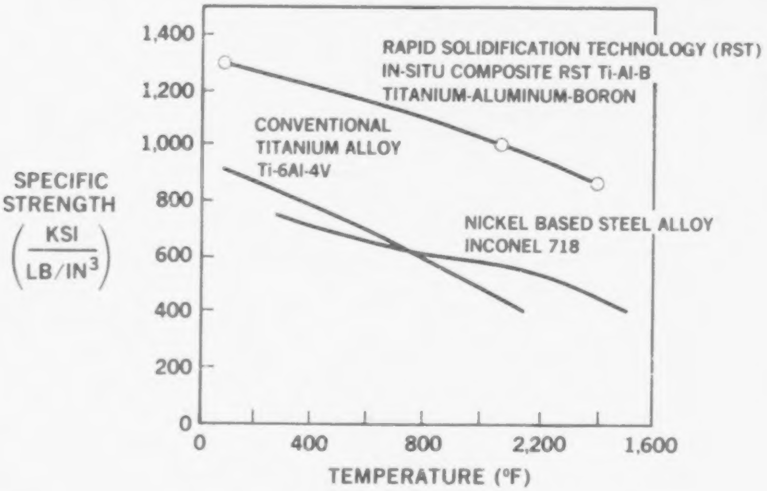


FIGURE 8.

Senator GORE [presiding]. Thank you very much.
Mr. Donohue.

STATEMENT OF THOMAS F. DONOHUE, GENERAL MANAGER, ADVANCED ENGINEERING TECHNOLOGIES DEPARTMENT, AIRCRAFT ENGINE BUSINESS GROUP, GENERAL ELECTRIC CO.

Mr. DONOHUE. I am Tom Donohue, and I represent the General Electric Co., which is a producer of aircraft engines and very interested in propulsion. We were exposed to NASP as a concept back in early February 1985 and were invited to participate in the activity which had been initiated about a year earlier by DARPA. We were immediately infatuated with the basic idea of a national aerospace plane, and quickly formed a study effort based on a combination of people, including old hands from the 1960's efforts and some of our most talented younger engineers. In pursuing propulsion system concepts, General Electric formed teaming agreements with Aerojet's Technical Systems Division and Garrett's AiResearch Division to bring together key expertise covering the broad operating spectrum covered by NASP propulsion. To date, well over $5 million has been spent in studies and in the fabrication of a demonstrator device which we expect to operate over the next couple of months. General Electric has applied a substantial effort of over 25 person years and has expended some $4 million of discretionary research and development money.

Now, General Electric and its team members have worked closely with the Government team of technical experts from both NASA and the Air Force which was put together by DARPA. Reviews of the effort undertaken provided the opportunity for technical exchange and for dialog on the program concepts and the plans between the Government team and GE. Of equal importance in formulating the propulsion system concepts have been the discussions and dialog with the airplane companies involved and ourselves. NASP, of course, represents a vehicle requiring far more interdependence and integration between the airframe and the propulsion system than anything yet envisioned.

Our initial contracted effort is expected to start within the next month. This will be a result of a proposal which was prepared and delivered to ASD of the Air Force in December of last year. This proposal features Aerojet TechSystems and AiResearch as major subcontractors and covers phase 2 of the program that the DARPA people showed you this morning.

Now, that is a 42-month program, and phase 2 is broken down into three segments. One covers preliminary design. The other covers component development and winds up with what is known as a module demonstration. This module is that section of the propulsion system which is similar to an engine in a conventional airplane or an engine in a conventional rocket and is to be designed and built by an engine company. This module is to be tested at a facility which can produce an environment as high in flight speed as we can practically do in a test chamber. Yet, this speed is very far short of orbital velocity.

At this time the Government is evaluating our proposal as well as the proposal submitted by our competitor, Pratt & Whitney. Two contract awards are expected in the program. The Government, of course, is also evaluating the proposals offered by five aircraft companies which will yield preliminary designs and key technologies for the vehicle.

General Electric remains very excited about the NASP concept and its prospects. The challenge of developing an orbital vehicle which has conventional takeoff and landing capability is really great. Unquestionably it is the high-risk enterprise described this morning. However, the payoff is just as great as the challenge for both military missions and the transport of civil payloads. Attaining the major objectives of operational flexibility, vastly reduced turnaround time and reduced support requirements will produce far lower cost to put payloads into orbit.

Now, in order to obtain these goals, a new type of propulsion system is needed to span the tremendously broad spectrum of operating conditions. Its success depends greatly upon the application of advanced technology in many areas. Hypersonic flow fields must be understood and predicted with great accuracy to establish structural heat loads and cooling requirements. Structures must be both low in weight and durable, thus requiring advanced materials and cooling technologies that can sustain the very high temperature environment. Duct flow will be supersonic over a large portion of the flight spectrum and at very high velocity in comparison with prior experience in supersonic combustion systems. This will require improved knowledge of the chemical reactions and complex chemical species which will form. The long life required for cryogenic propellant systems will demand enhancements in this technology as well.

Our current program addresses these technical needs. This program is in concert with the very sensible phase-by-phase program plan formulated by the Government. Yet, it must be recognized that we are only at the beginning and we must be prepared for changes in program scope as technical issues become clearer and better defined.

General Electric sees the program as one which provides the propulsion concept for a flight demonstrator vehicle. While testing the complete module itself is limited to around Mach 8 for ground facilities, expansion of the flight envelope by vehicle test appears appropriate. Certain key data at even higher Mach numbers, even approaching orbital speeds, can be obtained from short duration facilities like the CALSPAN shock tunnel. However, much reliance must be placed on the application of the recently developed computer fluid dynamics on super computers in order to define in detail the operating conditions.

Comprehensive analysis will play a far greater role in developing NASP than in any other vehicle. An identified area of concern is the lack of an ability to demonstrate functionality, and then subsequently test for the durability of a full engine module throughout the lower speed end of the flight spectrum. We intend to study the potential of the recently completed ASTF facility at the AEC in Tullahoma to see if modification will allow continuous operation from nearly static conditions up to stable SCRAMJET operation at mach 5.

Overall, General Electric studies to date have shown no barrier problems that would halt a successful NASP. Undertaking the challenge now with the program defined by the Government is entirely appropriate. The favorable military and space systems prospects make NASP a must program in our opinion. General Electric hopes to play a major role in its development.

The evolution and formulation of the NASP Program strongly addresses one of the three major thrusts in aeronautics posed by OSTP about 1 year ago. There is likely to be technology synergy between NASP technical developments and the elements needed for high speed transport which would be particularly useful for the Pacific rim. However, General Electric views this thrust as an advanced aircraft carrying hundreds of passengers at supersonic speeds by around the year 2000. Very little effort is being expended either by the government or by industry to explore whether the technologies of the 1980's can provide a viable system of this type. The third thrust, revamping the subsonic fleet for much improved economics is making some progress through considerable industry effort and modest Government support in developing the basic technologies.

But it is NASP that has captured everybody's interest. It is an exciting concept and holds the promise of a great adventure in aerospace.

Senator GORE. Very good. Thank you all.

First of all, do each of you agree with the assessments given by the last panel about the timeframe and the costs? Do any of you have any reason to make different predictions on the timeline or the cost?

Mr. DONOHUE. They are generally correct. It is very difficult to forecast any significant improvements or pull-ins of those kinds of dates at this time. It could be that people, or we or anybody could get lucky and things could be accelerated, but I think we heard a realistic assessment today.

Mr. SCHAUFELE. I would certainly support that from the standpoint of doing the technology work and the timetable that has been forecast for getting into a flight research vehicle. I also think that the broad term vehicle applications that have been discussed, the timeframe for those is realistic, but again, will depend obviously on the developments that come out of the flight demonstration.

Dr. KRONE. My comment is that they are realistic based on not running into what I would call insurmountable problems. The risk has been described I think adequately here, and with these kinds of risks, you always have that potential problems. With, I will say, a little luck, we could make that schedule.

And another aspect of that is the actual performance level or levels that the research vehicle is required to meet. They may be modified during the technology program, and I would like to say that even if the most optimistic performance levels are not reached, a degree or a large portion of those levels would still be major advances and a useful product.

Senator GORE. The other witnesses have been asked what are the reasons for initiating the National Aerospace Plane Program now in light of the current budget environment.

Could each of you respond to that question?

Mr. DONOHUE. I think the now part of it is very much associated with my perception, at least in my view, of the military needs.

Whether it is a time-matched effort for superseding shuttle ultimately and so forth, that could be debated, whether a year or two slip would make much difference. I personally foresee some very good application for the military side, and I think it should be started now.

Mr. SCHAUFELE. I think from our perspective the reason for doing it now is primarily associated with the military applications; secondarily with having the technology available for the next round of shuttle capabilities; and thirdly, for the potential for future commercial applications. I think the first two are overriding, to have the technology start now so that we do not lose leadership in both the military area and in the space area.

Dr. KRONE. I would totally agree with those two assessments and only add that the technology developments that in reality were not directed specifically at the hypersonic area; namely, materials and super computer work, have all of a sudden sparked a rebirth of the interest, and the applications aspects of it are rather varied. And if we are ever going to get to those applications in the relatively near term, in other words by the 2000 time period, we have to start now, and we have to put a critical mass of resources behind the program.

It is a major undertaking, and it has to be recognized as that. And a piecemeal, more or less, dribbling approach essentially will not get us to our objectives in even the year 2000 timeframe.

Senator GORE. When you all cite the military applications as the principal reason for moving ahead now, do you have in mind principally the need for a much cheaper launch procedure for components of the space-based SDI? Is that really what you are thinking about?

Mr. DONOHUE. A major part of it I think is really the flexibility in having a vehicle that can take off from different locations in the continental United States and launch payloads at very short notice is probably the most outstanding reason for it.

Senator GORE. But it is not hinged to a very large extent on SDI in your mind?

Mr. DONOHUE. Well, it could well become that. I cannot comment very much because my exposure to SDI is very fragmented technology effort, and the systems and concepts have yet to be really defined as to what they really want to put into orbit.

Mr. SCHAUFELE. I guess I would say that the number of potential military missions, some of them fairly well defined and some not so well defined, really are the drivers in my mind. The fact that we do not want to lose leadership in those areas as compared to what is going on in other countries is a reason to get the first steps taken at this time rather than delaying it for future activity.

Senator GORE. Did you want to comment on that, Dr. Krone?

Dr. KRONE. Just one other word on that. The military applications are varied and do not necessarily require the complete accomplishment of all of the objectives of the Research Vehicle Program, and what I mean by that is mach 10, military reconnaissance or even strategic strike vehicles at that speed and at high altitudes are required to fly at those speeds would be a very valuable additional option to our arsenal.

Senator GORE. What would you expect to be the length of time between military applications and commercial air transport applications?

Mr. SCHAUFELE. Well, let me try that one. It is very difficult to predict how much time would be involved. I think that it depends, critically, on a demonstration of the technical capability, and second, it depends very much on the economic viability of a commercial transport application. I think only when you have the technology in hand, when you have the background to be able to accurately predict not only the performance of the vehicle but also accurately predict the manufacturing cost, the operating cost, can you really put together the mechanism for viable commercial application.

It could be that that process could be reasonably short. In looking back at experience in the supersonic cruise area, it could be quite long. It depends very much on the factors that I just mentioned in putting together a viable commercial program.

Senator GORE. Is it reasonable to speculate that the incremental cost of one of these planes might very well be so high as to make its use as an airliner never feasible?

Mr. DONOHUE. I am guessing that that is impossible. You cannot have a program that would be viable in any context of the word unless the costs are competitive.

Senator GORE. The costs for what were competitive?

Mr. DONOHUE. The total costs of operating the vehicle, the incremental costs of tickets relative to coach fares and all of that kind of stuff gets into the same kind of situation with Concorde. Unless we can forecast that the system is really viable from an economic standpoint overall, there will not be a program.

Senator GORE. Well, you are talking about a civilian program.

Mr. DONOHUE. Right.

Senator GORE. Well, insofar as a great deal of support for this initiative in the Congress will rest upon a perception that it is going to be the new Orient Express, in President Reagan's phrase, and is going to take people from Washington to Peking in a couple of hours, I think that we ought to know on the front end if it is actually likely that that will be impossible, and instead, it will end up being merely—not merely, but it will end up being principally a military vehicle with military applications.

Mr. DONOHUE. I would like to clarify, I guess, what I meant. The technical feasibility of doing that is real. The issue is whether or not it is possible to formulate a program without the projected and carefully forecasted results being economically viable. If we come up with another SST like we did back in 1971, I guess, is when the program was canceled, and forecast it, it is an impossible program, we cannot afford it. It will not be economically viable.

Dr. KRONE. Could I add to that, sir?

Senator GORE. Yes, but I am not quite sure what your answer is. I am not sure I understand what you said there.

You are saying if it is not possible, it will not be possible.

Mr. DONOHUE. Even with technical feasibility, it is far from being enough to expect the United States or other Pacific rim countries to invest in a program.

Senator GORE. OK.

Mr. DONOHUE. Technical feasibility alone is totally insufficient.

Senator GORE. I understand that. The question I am asking, though, is this, is it not likely that new vehicle will not prove to be economically feasible for use as an airliner? I do not want to frame it in a way that points the answer in a particular direction, but I am getting the impression from you all that the military applications look very exciting. We are looking forward to that prospect. But you are sort of steering us away from the civilian applications. Is that correct?

Mr. SCHAUFELE. Senator, let me try to clarify that a little bit. The emphasis that we put on the military application were, one, the pressing requirement to do the technology program and the flight demonstrator early. I think that is the key. In looking at the potential for commerial application, we have made some very preliminary studies on whether or not if all of the objectives technologically are achieved, trying to look at the very broad scale cost calculations. There is nothing in that situation at the moment that would lead us to believe that we should rule out the civil applications. It looks to us like very possible to be able to formulate a viable commercial program, if all of the technology pans out and the cost factors which we have to assess turn out to be the way we expect them to be.

Senator GORE. You think it would be?

Mr. SCHAUFELE. We think it would be possible, yes, sir.

Senator GORE. Now, just as a ballpark estimate—and I know you do not want to do that—but just as a ballpark estimate. Is it a reasonable contention that each one of these planes might cost roughly the same amount as an orbiter in the shuttle program?

It seems to be much more complicated and a great deal more sophisticated. Would you expect it to cost more, less, or about the same as an orbiter?

Mr. SCHAUFELE. I guess I am not really pepared to answer that because I really do not know what an orbiter costs.

Senator GORE. About $2 billion.

Mr. SCHAUFELE. Well, it would be really hard to predict at the moment whether it would be more or less or there abouts. After all, whowould have thought some years ago that the 747's would cost over $100 million apiece. But in trying to take into accountsome fairly significant cost parameters on the part of the vehicle itself, but then looking at the extreme productivity that a vehicle of this type would provide in a commercial environment, it looks like there is a good possibility that you could put together a program.

Senator GORE. All right. Now, let's just say for the purposes of inquiry here that one of these vehicles ends up costing not more than, but just as much, as an orbiter. Can you conceive of a commercially viable airplane carrying passengers if each one of them costs $2 billion?

I mean, the advantages to the passenger are rather dramatic. Instead of a 15-hour flight, you have got a 2-hour flight across the Pacific Ocean. But if you do the arithmetic on what each ticket would cost, I wonder if it is really realistic for commercial air traffic?

And I am just asking. Would you agree that if the cost turned out to be the same as that for an orbiter, would it really be feasible as a commercial aircraft?

Mr. **Schaufele**. I do not think we can conclude that at this point.

Senator **Gore**. You do not?

Dr. **Krone**. Well, let me make a comment to the question of the possibility, in other words, is it possible that this would be an economically viable means of transportation. I think the answer to that is definitely yes. The real question here is when. That relates to the cost and the ability to build and to operate this type of a vehicle relatively cheaply.

And so consequently, that also depends upon the technology development, namely, the manufacturing development, et cetera, that can be advanced at the same time that the technology for the actual feasibility of the vehicle itself progresses.

So it is really a question of when.

Senator **Gore**. I do not want my line of questioning to be misinterpreted. As I said earlier, I strongly support this program. I want to see what the feasibility is, and I think we ought to get started as quickly as possible, with a research program.

But I want to preserve the ability of the Congress to look at this thing objectively each step along the way. Let us not have some unrealistic illusion about what its capabilities really are. And I am not referring there to the speed or the time in which it can travel between two points at all.

I am referring to its potential as a replacement for commercial airliners, because that is where a lot of the public appeal is. That is the aspect highlighted by the President.

The 80 percent of the program that is military will be funded. Now, if it is likely to have no civilian or no air transport capability at all, we ought to know that.

Mr. **Schaufele**. Let me proceed that a little further. First of all, I would agree with your comments that you really have to, even at a very early stage, assess in a broad way whether this concept has any potential for commercial application. I think the gist of my testimony is clearly that we believe it does. And we need to pursue not only the technology but also the system studies and the cost studies, in order to prove that point.

One thing I would like to comment about your comparison with the shuttle orbiter cost, we are talking about a program there that is going to have several hundred vehicles involved and surely the high cost.

Senator **Gore**. Well, that, too, depends upon the cost, does it not?

Mr. **Schaufele**. Yes, it does. But it depends really on the demand—on the market demand for this type of product.

Senator **Gore**. Now, let me explore that for a minute. You say several hundred. What is that projection based on?

Mr. **Schaufele**. It is based on a projection of the traffic growth in the Pacific-rim countries.

Senator **Gore**. Air transportation of people?

Mr. **Schaufele**. Of people and cargo. But people, primarily.

Senator **Gore**. If it is primarily a military and civilian satellite launch vehicle, those are its primary missions and it turns out that it is economically absurd to try to sell tickets to the flying public at a cost that covers thei. expenses, then you are not going to need several hundred for that for the first two missions?

Mr. SCHAUFELE. I am talking about several hundred commercial vehicles. That is kind of a potential market that would exist just due to the requirement for moving people and cargo in the Pacific rim and for other routes that are over, say, 4,500 nautical miles.

Senator GORE. Well, there is always the hope that thecost would come way, way down.

Mr. SCHAUFELE. The point I was trying to make there was that a lot of the development cost in a vehicle program that encompasses several hundred vehicles can go a long way to offsetting the cost per vehicle. If you are only going to build four or five shuttles, obviously, the individual cost of each one is going to be very high.

Senator GORE. Well, mark me down as skeptical about the airline possibilities. I hope that they emerge. But in evaluating it, I think I would have to be very skeptical about that.

In terms of the critical technologies for the plane, there seems to be general agreement that propulsion materials and aerodynamics are the key enabling technologies; correct?

Mr. SCHAUFELE. Right.

Senator GORE. In your view, are all of these resolvable or is therea significant chance that one or more there might be a so-called show-stopper?

Dr. KRONE. I will answer that. I think that there is sufficient evidence from laboratory experiences as well as analytical analysis that the levels required for a practical vehicle are attainable, technologywise.

Again, there are risks in the amount of resources that will be needed to reach those levels and particularly the time required. I mean, the real risks are in time and resources that would be required.

Senator GORE. Would anyone else like to respond?

Mr. DONOHUE. Well, real barriers come about when you are trying to defy physical laws. And so far for really the vehicle and propulsion and particularly on the propulsion side, we have done enough work, I think, to feel that there are no real barrier problems.

The performance of the vehicle may prove somewhat deficient, let us say, from earlier forecasts. But it would still be a good vehicle. It is going to be a lot of work to do all of the things that have to be done and, frankly, we do not know what the cost and so forth would be.

It will take another 2 years before we really understand what we are into.

Mr. SCHAUFELE. We would support the idea that the key technologies that have been identified are the ones that need to be reduced through engineering effort to practical application. And we do not see any real show-stoppers in that line.

Senator GORE. Earlier witnesses were asked about spin-off technologies. Do you see any significant spinoffs that you would like to highlight?

Dr. KRONE. Well, I will comment that there are a number, and the obvious ones being the materials and structural analysis spinoffs. Much of that work will be directly applicable to the other goals: the subsonic and the supersonic crews and applications, as well as a potential use in commercial products—that is, materials work, the increased emphasis in the computational aerodynamics, thermodynamics and the ability to predict.

The complex-flow parameters will also be directly applicable to other vehicles. So even if we did get to a point where we decided that it wasn't feasible to go ahead with an application immediately, then I think the technology developed would be applied directly to these other areas.

Mr. DONOHUE. I would like to reaffirm that from our side. In the propulsion business, even gas turbine engines, as we know them today, are highly dependent upon all of the things that go on with all of the technologies that will evolve from activities with the exception, perhaps, of the actual hypersonic fluids, problems themselves.

The heat transfer, cooling, high temperature materials, better materials understanding, all of those things, computer codes are all very necessary to continue to enhance our own technology base.

Senator GORE. Well, those are all of the questions I have at this point, and I would like to ask your indulgence, if you will. The chairman, Senator Gorton, will be back within the next few minutes, and I am late for something else. What I am going to do is call a short recess in this hearing, and the subcommittee will reconvene in just a few minutes when Senator Gorton comes back.

We will stand in recess temporarily.

[Brief recess.]

Senator GORTON [presiding]. Please accept my apologies for having been called away and for keeping you waiting. I appreciate your awaiting my return.

According to Mr. Schaufele's testimony, a mach regime of 5 is the most economical or perhaps the highest economical mach regime that you have set for commercial hypersonic transport.

Do the rest of you agree with that? Do the other two of you agree with that proposition?

Dr. KRONE. I will speak first. Relative to the limiting mach number, I think that we could think in terms of higher than 5 eventually. It is a question of time and resources and technology development. An honest answer is that I do not think there is any question about the fact that it could be extended well beyond 5, but from a commercially viable standpoint, the real question is how long it will take to do it.

Senator GORTON. Mr. Donohue?

Mr. DONOHUE. I really cannot jusify or augment Mach 5 as being the right answer or whether it is higher or perhaps even somewhat lower. I think there is a need for a vehicle, and we have to determine what is the right vehicle.

Senator GORTON. How soon after the completion of a flight research program could a commercial hypersonic transport aircraft be available, would you guess, any or all of you?

Mr. SCHAUFELE. Let me try that. We discussed that a little bit with Senator Gore, but I think in terms of the ability to do a program, it could come quite closely on the heels of a flight demonstrator vehicle. The key element in a commercial program is the commercial viability of the program, but I think that depends on not only demonstrating the technology, but also getting the cost factors well identified.

Senator GORTON. You said while I was still here that major costs of this program are the cost to build, the cost to operate and, the cost to ensure reliability, and then I was impressed with your last point which of course reliability, that you could use such a vehicle four times as often as you could a subsonic jet.

Did I get that correctly?

Mr. SCHAUFELE. You did correctly, and that is one of the real keys to the commercial success of the hypersonic transport is the high productivity that could be achieved with the kind of speeds and the kind of ranges that the vehicle could operate over.

Senator GORTON. Do either of the other of you have any comment on that?

Dr. KRONE. Venturing an analysis based on past performance and the experience we have relative to supersonic transports there are some who believe that we are very near the time when we could build a, say, mach 3, or close to mach 3 supersonic transport that would be commercially viable, in other words, ticket sales not a whole lot greater than a subsonic airplane, and we are now some, oh, 20 years past the point of technical feasibility to do that, or even more than 20 years.

If you were to judge by that, by that standard, you would come up with a number like the year 2015 or so, and I do not know what better yardstick we have.

Senator GORTON. Thank you.

Mr. DONOHUE. I would like to pose that the answer to the question could be a little different. When the Concorde was initiated, mach 2 military airplanes had been flying for a considerable period of time, efficient military airplanes for supersonic flight. If I remember correctly, Concorde went through a 2-year introduction phase before passengers were flown, proving flights because it was a new airplane and a new speed regime, and warmer, higher temperatures and so forth, and I would expect that a comparable kind of program to Concorde would result after an operational vehicle was done for a hypersonic-type airplane, meaning that it is likely that there would have to be some type of military program which would be the proving ground for developing the reliability and so forth before we start putting people on it.

And then you would have a comparable program to Concorde in terms of its time, maybe stretched just a modest amount, like 30 to 50 percent.

Senator GORTON. The DARPA witness told us that we ought to be able to deliver payloads into space somewhere between 10 percent and 1 percent of the cost of doing so with the orbiter.

Perhaps one or more of you would like to comment to me on how this is possible? What are the profound technological differences and challenges that could yield such an obviously dramatic improvement?

I might have asked him that, but I would like to have comments from any of you on that subject.

Dr. KRONE. Well, my comment to that is that there is a combination of advantages of the aerospace plane-type vehicle, the obvious one being that you do not have to carry your oxidizer therefore the entire size and weight of the vehicle, does not have to be as potentially high on takeoff, and weight and size means a lot when it comes to delivering payloads.

The other factor I think that is included in that rather large estimate is the fact that that estimate is relying on a technology level that is considerably advanced to the current shuttle program, and that goes for the propulsion system as well as the materials and the reduction threshold of the structural weight fraction for the vehicle.

And so I think we are seeing there with those estimates approximations of what possibly can be done. And the exact level of the realization of those approximations would have to wait until we see where we do progress to with the technology program.

Mr. SCHAUFELE. I think a lot of the expectation of cost reduction comes from really significant reduction in the ground facilities required, the complete reusability of the vehicle, the fact that you do not have to put on a lot of external fuel, and it takes all of the oxygen from the atmosphere, and just a number of benefits that are associated with airplane-like operation as opposed to really complex vehicle operation like shuttle.

Mr. DONOHUE. I agree mostly with Mr. Schaufele's assessment on that. The targets of taking off conventionally and then having absolute maximum of days or maybe even hours of turnaround time on the ground would really take and reduce the massive number of people involved with ground operations and facilities upgrades and so forth associated with shuttle right now, and bring them into more or less conventional airplane operations, either the military example—well, the military example would probably be better than a standard commercial example.

Senator GORTON. For the two of you, Mr. Schaufele and Mr. Donohue, what kind of activities have your respective companies conducted in support of the aerospace plane program?

Mr. SCHAUFELE. Let me try that first. We have done a number of in-house research and technology efforts directed along the lines of materials, structural application of the materials. We have done some overall broad system studies of the type I have described in commercial applications. We have a fair amount of activity in computational fluid dynamics, which is another key area to the aerospace plane program. So there are a number of small but significant internal research activities that our corporation has conducted which all fit together in the total national aerospace plane program.

Mr. DONOHUE. Well, we have done more in the line of design studies, trying to undertand the problems involved, what we have to do in order to produce a reliable and effective propulsion system. I think we have spent within General Electric, I know we have spent well over $4 million in this area in the past year. Further, we have teamed with Aerojet TechSystems and AiResearch who have supported us in some respects. We have built hardware and are starting to do some demonstrator type experiments on various aspects of propulsion system on our own.

So right now we are looking forward to getting a contract to start developing some of this work.

Senator GORTON. Dr. Krone, according to your written testimony, reducing the structural weight of an aerospace plane depends heavily on building what you call a practical vehicle.

How do you use that word practical? What is a practical vehicle?

Dr. KRONE. Well, in the commercial world it is a vehicle that can economically compete with a competitor or a competitive method for doing a similar mission. And if you talk in the military sense, the practical vehicle is more defined as one being able to accomplish a military mission in a more efficient way with the ability to defeat the enemy threat.

So it is really kind of two, it is kind of a two-edged word in that sense. And in my testimony or in our testimony, I stated that I thought that from the commercially practical standpoint, in other words, as a transport, it would be further downstream than a practical military vehicle for meeting threats, and from the structural weight standpoint, there is obviously a threshold where the cost and the closure on design procedures makes it possible.

Senator GORTON. Finally, for all of you, what kind of additional national facilities must be developed or enhanced in order to support an aerospace plane program? Are we talking about anything remotely comparable to the Kennedy Space Center or Johnson Space Flight Center or the like?

Mr. SCHAUFELE. I think there are a number of facilities that already exist that can do a lot for the National Aerospace Plan Program, facilities within NASA and the Air Force facilities complex. From our standpoint, we do not see any major facilities like another Johnson or Kennedy Space Flight Center being required to achieve the goals of the National Aerospace Plane Program.

Mr. DONOHUE. In our looking at this problem we found one deficiency. We would like to think that an upgrade of ASTF facility in Tullahoma, TN, that would be a desirable thing to do. We need a facility that will allow progressive low speed validation through the flight envelope up until we get to hypersonic speed. The hypersonic speed is reasonably well covered. It would be nice to have facilities that would go higher in mach number than those that are currently being planned, but I think we could live without them.

Dr. KRONE. The committee that I chaired looked at this question in a realistic way, I guess, or we kind of worried about this question, and the feeling was that much of the design effort for the aerospace plane, the research vehicle, to start off with, and then any applications after that, would be through the computational, computer-generated methodologies and codes, and that those codes are—have come on the scene relatively recently. And there is a requirement, we feel for a validation of those codes throughout the mach number and speed ranges, altitude ranges that your vehicle is expected to fly in. We felt, or the committee felt a study should be made to see just what facilities are needed to validate the codes, not necessarily facilities to test the full scale vehicle through its full range.

And so that was the reason for the inclusion of that item in our testimony.

Senator GORTON. I would like to thank the three of you for your assistance and for your enlightenment.

Again, I apologize for keeping you longer than necessary, but you have been very helpful. Thank you very much.

We are adjourned.

[Whereupon, at 12 o'clock noon, the subcommittee recessed subject to the call of the Chair.]

NASA AUTHORIZATION

THURSDAY, APRIL 10, 1986

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE,
Washington, DC.

The subcommittee met at 2:07 a.m. in room SR-253, Russell Senate Office Building, Hon. Slade Gorton (chairman of the subcommittee) presiding.

OPENING STATEMENT BY SENATOR GORTON

Senator GORTON. Welcome to this hearing of the Subcommittee on Science, Technology, and Space as it reviews the fiscal year 1987 authorizations for NASA's Office of Commercial Programs, and the Office of Space Science and Applications.

As we anticipate the emergence of the commercial development of space, we become increasingly aware of the importance of coordinating the resources and capabilities of Government, industry, and academia. NASA's Centers for the Commercial Development of Space are an innovative concept designed to maximize these talents, and we look forward to hearing about the progress of the five centers that have been established, as well as about the prospects for additional centers.

It is this subcommittee's hope that NASA's Office of Commercial Programs will create and maintain the necessary environment to foster the Government-industry-academia partnership that is so important in these early stages of space commercialization. For example, NASA's Joint Endeavor Agreements have in the past contributed to the early entry of the private sector into the risk-filled business of space, and today we look forward to a discussion of the efficacy of these agreements in removing some of these risks for the private sector.

As this subcommittee reviews the authorization for Space Science and Applications, we are reminded how 1986 was being billed as NASA's "Year of Space Science," with the launch of the Hubble Space Telescope and the Galileo and Ulysses missions. Now we are faced with the tragic irony of a year that fills none of these long-awaited dreams.

Nevertheless, as we await the resumption of shuttle flights and the launch of these and other missions, we must maintain a productive and meaningful agenda for our science and applications programs. The wait may be long, but I believe we will not be disappointed once these missions begin to unravel some of the mysteries that have puzzled mankind for centuries.

With this, and before our witnesses testify, we have the distinguished ranking minority member of the parent committee, Senator Hollings.

OPENING STATEMENT BY SENATOR HOLLINGS

Senator HOLLINGS. I thank the distinguished chairman and the members of the committee. I will just read my statement, if you do not mind, for the record. I also would like to thank our friends at the Langley Research Center and NASA for their continued support.

We had a can-do experiment developed by the Williams School in my own home town with the students, parents, teachers, the advisors from NASA, the National Geographic Society, and the Medical University. This of course was lost in the shuttle disaster, but I understand that we are now rescheduled whenever we go again an opportunity to fly on a NASA aircraft, that that particular experiment will be taken.

And we do appreciate that, and support for our bicentennial celebration, which we will have May 24 and 25. That's in the capital city of Columbia. Christa McAuliff was scheduled to be with us. Others of the astronauts have agreed to fill in and be there and carry forward with the celebration. And it really is; it will be a celebration in sobriety, but also of joy, for the courage of those that have been lost.

And I am glad that we are now proceeding where we can at least get in on the budget.

Mr. Chairman, 1986 was to have been the most exciting and far reaching year ever recorded in the annals of U.S. space science. The Uranus fly-by, the Halley Mission, the launch of the Galileo, Ulysses, and Space Telescope satellites were to let man take a giant leap forward in probing the universe. And until January 28, it looked as though 1986's accomplishments could exceed even the greatest expectations. The Voyager fly-by of Uranus in January provided incredible data and information and dazzling discoveries. With the Halley Comet encounter soon to occur, 1986 seemed to be living up to its billing as the "Greatest Show in Space." However, in less than 2 minutes on January 28, those dreams came to an abrupt halt.

Mr. Chairman, the *Challenger* disaster left this Nation's space program in a state of disarray. In particualr, the space science agenda was dealt a severe blow. Launches have been canceled and potential new starts have become less likely as budget pressures come to bear in the aftermath of the disaster. Instead of funding new activities, space science dollars will be used to salvage existing activities until they can be flown on the shuttle. The effect on the investagotors, the research centers, the universities, the contractors and the overall program is incredible. How long these missions will be grounded is still anybody's guess. But it is quite clear that our space science and applications programs, the very heart of our R&D activities at NASA, will require serious attention and support.

The area of space commercialization has also been dealt a severe blow—a blow to expectations of new space based products, improved ground based processes, and technologies. What was to have been the start of a new era—the era of space commercialization—will now be delayed. But hopefully, during the shuttle's down period, a new era of realism will be commenced—an era in which people say what they mean and not what they hope; an era in which space policy is formulated on pragmatic assumptions, not rhetoric; and era in which the private sector is given more realistic opportunities to provide goods and services that are now the domain of the Government; but not an era where Federal programs serving the national interest are sacrificed as part of the gamesmanship of the budget process.

With the advent of the shuttle, space commercialization was given new life, new opportunities, new meaning. Having once been limited to communications satellites, space began to present challenges and opportunities to pharmaceutical companies, ceramics industries, electronics firms, and manufacturing industries. We had just begun this exciting journey into space ventures when the *Challenger* exploded. Now, we must regroup, readjust our schedule, realign our budget, and put our journey back on track.

Mr. Chairman, I look forward to today's testimony and to a candid exchange between our witnesses and the members of this committee. If there is any one lesson to be learned from the *Challenger* accident, it is the need for NASA and the subcommittee to communicate openly.

Today, I hope to hear what policy options are being assessed by the Offices of Space Science and Applications and Space Commercialization and what the budgetary consequences of the shuttle tragedy are on the various programs in both fiscal year 1986 and fiscal year 1987. If a realistic fiscal year 1987 NASA authorization bill is to be reported out by this committee, it is essential the committee be fully aware of the policy and budgetary options being considered by NASA in 1986 and 1987. I look forward to hearing today's testimony and to working with NASA to reestablish vibrant space science, space applications, and space commercialization programs.

Thank you.

Senator GORTON. Senator Riegle.

OPENING STATEMENT BY SENATOR RIEGLE

Senator RIEGLE. Thank you, Mr. Chairman.

You might know there is some interesting discussion taking place on the Senate floor right now as to whether tax reform comes ahead of the budget or the budget comes ahead of tax reform. I was involved in that debate and so was not able to be here exactly at 2.

Senator GORTON. I would like to be there myself, Senator.

Senator RIEGLE. I hope I expressed a view that might incorporate your thinking, as well as my own.

But in any event, I do have a statement I would like to make at the outset, and I appreciate the importance of our beginning today in this very important work that confronts us. This is the first of a series of hearings that this subcommittee will be holding to develop and refine NASA's budgetary requirements.

Clearly, the entire structure of NASA was shaken on January 28, when the *Challenger* disaster occurred. With the exception of the aeronautics program, every single NASA activity was affected by this tragedy.

Consequently, all budget planning and preparation within NASA and in the Congress has been in a near-total state of suspension, a fact that was reflected in our deliberations on the Budget Committee. And that, I might say, is a committee on which the three of us all serve together, and so we have attempted to do what we could do in that forum in the light of such radically changed circumstances.

Obviously, we are not able to wait any longer, nor is it prudent to wait any longer. And I agree with the chairman that critical decisions must be made by this subcommittee, decisions which will hopefully help put NASA's operations back on track insofar as the role as we have to play in that.

We have agreed with the chairman—there has been some discussion about this and some difference of opinion, but we have agreed to postpone detailed oversight activities with respect to the Rogers Commission or to the *Challenger* accident itself until after the final report of the Commission is issued.

But it is my understanding that we will receive an interim report from Secretary Rogers on the progress of the work of the Commission, as he has previously given us a size-up of that effort, and when it is completed it is my understanding that we will have an opportunity then to take and look with some great care at the findings of the Commission and any remaining questions that it would be important for us to examine in terms of this subcommittee's work.

The hearing today will focus upon the scientific and commercialization work of NASA, which I consider to be very, very important to this country's future. It is programs within the scientific area of NASA that have brought us all a closeup view of Uranus by the *Voyager* spacecraft. Indeed, it is the scientific program that has served to capture our imagination and maintain our curiosity over the years with visits to many far-off planets and which has continued to take us out to the outer reaches of space.

The loss of the *Challenger* has a direct effect on the immediate future of the scientific programs. Two critical missions were scheduled for this year, the Ulysses and Galileo probes, as well as the launch of the space telescope, which is for the purpose of giving us the most distant views of the universe ever obtained by mankind.

With the entire launch schedule thrown off, there is a real fear that scientific missions will take a backseat role to military and commercial payloads in the future. We are going to have to work our way through that, but I want, just as one member of the Senate and this committee, to assure the scientific community that I will do all that I can to try to preserve the balance between commercial, military, and scientific payloads once NASA begins shuttle operations again.

I think that balance has been critical to the progress that we have made over a long period of time, and I think it will continue to be critical to the progress that we make in the future.

The other focus of today's hearings is the status of NASA's commercialization program. This too, of course, was adversely affected by the *Challenger* loss, and that disaster compounded the uncertainty that has afflicted launch schedules.

One area that I would like to explore is the need to not only rationalize the launch scheduling process, but I have significant doubts that we could ever have reached a 24-flight per year schedule with a four orbiter fleet. And yet, the commercial users were continually told to base their plans on that projection.

And so I would hope that as we work our way through today's problems, that we will emerge in the post-*Challenger* accident environment in a way where we have a renewed commitment to provide the commercial users with information that in fact they can truly depend upon.

I think to leave commercial users in a situation where they are likely to be very adversely affected even absent disasters of the scale that we have seen I think is not prudent, I do not think it is necessary, and I think we ought to work harder as a government entity to try to avoid that kind of complication.

Mr. Chairman, there are many areas that we could delve into during this hearing, such as the status of NASA's research and development efforts, their cooperative arrangements with universities around the country. In addition, we need to begin the process of putting together a schedule of missions so that we can have an accurate picture of the launch requirements that we are going to be facing here.

I would just make one final comment, and that is that we have been working over a period of weeks to try to come to a sort of common point of view as to how best to proceed, and I think we have managed to do that. I think there has been a good working relationship established with the chairman of the subcommittee in working out an orderly way in which to examine these questions.

I appreciate the fact that we have been able to put that schedule together, and I look forward to working with the chairman and following through on these items.

Senator GORTON. Thank you, Senator Riegle, for those kind comments.

And now, Mr. Gillam, we will turn to you and welcome you back to the subcommittee again. And we would be happy to hear what you have to say.

STATEMENT OF ISAAC T. GILLAM IV, ASSISTANT ADMINISTRATOR FOR COMMERCIAL PROGRAMS, NASA

Mr. GILLAM. Thank you, Mr. Chairman.

Senator GORTON. As usual and as you know, your entire written statement will be included in the record.

Mr. GILLAM. Thank you, Mr. Chairman. I was about to ask you and the members of the subcommittee's indulgence, if that statement could be made for the record. With the use of some charts that I have provided to the members of the subcommittee, I would like to give a narrative overview of how our budget was formed.

Senator GORTON. Please go right ahead.

Mr. GILLAM. Starting from the national goal that was a part of the President's national space policy—that goal of increasing private sector investment and involvement in civil space activities in the applications of aeronautics and space technology to that sector, to maintain U.S. leadership in space—that goal became the mission of the Office of Commercial Programs when it was formed.

We took that mission, as indicated on chart number 1, (figure 1) and with some planning assumptions that were derived both from the external community—the private sector, the university community, and other outside communities—and from some internal data, we derived the specific objectives of the Office of Commercial Programs. There are four specific objectives currently

GOAL/OBJECTIVES

GOAL

Increase private investment and involvement in civil space activities and the application of aeronautics and space technology to maintain U.S. leadership

OBJECTIVES

Establish close working relations with private sector and academia to encourage use of and investment in space technology

Facilitate private sector activities through access to available U.S. Government capabilities

Encourage private investment independent of NASA funding

Develop and oversee consistent NASA-wide implementation of commercial space policy

FIGURE 1

The first objective is to establish a close working relationship with the private sector and academia to encourage use and investment in space technology. The second one is to facilitate private sector activities through access to available U.S. Government capabilities. The third is to encourage private sector investment independent of NASA. And the fourth is to develop and oversee a consistent NASA-wide implementation of the commercial space policy.

With that goal and those objectives as a starting point, we formulated the program elements that we initially are using within the Office of Commercial Programs that are indicated on the second chart (figure 2). Those program elements are three major elements: The Commercial Use of Space; the Technology Utilization program, which you are familiar with, that has been a part of the NASA program for over 20 years; and finally, the Small Business Innovation Research Program.

PROGRAM ELEMENTS

COMMERCIAL USE OF SPACE

Commercial applications R&D: Centers for Commercial Development of Space; Commercial R&D enhancements.

Commercial development support: Outreach; Studies and analysis.

TECHNOLOGY UTILIZATION

Technology dissemination: Publications; Dissemination centers; Program evaluation and support.

Technology applications.

SMALL BUSINESS INNOVATION RESEARCH

FIGURE 2

These elements, when combined on the third chart (figure 3) with the objectives—and I might add that, whether or not they are direct in supporting is a judgmental question that we are still debating. The dark circles and the open circles on the charts, as indicated, sometimes will change as the program changes and as it evolves.

PROGRAM ELEMENTS/OBJECTIVES

	Objectives			
	Close working relations with private sector encourage use/investment in space technology	Facilitate private sector space activities through Government capabilities	Encourage private sector investment, independent of NASA funding	Develop and oversee consistent NASA wide implementation of space commercial policy
Program Elements				
1. Centers for commercial development	(1)	(2)	(2)	
2. Commercial research and development enhancement	(2)	(1)	(2)	(2)
3. Studies and analyses	(2)	(2)	(2)	(2)
4. Outreach activities	(1)	(2)	(1)	(2)
5. Technology dissemination	(1)	(2)	(2)	(2)
6. Technology applications engineering	(2)	(1)	(2)	(2)
7. Small business innovation research	(1)	(2)	(2)	(2)

[1] Direct [2] Supporting

FIGURE 3

But we have connected our program elements as indicated on the second chart with our objectives as indicated on the first chart, and we have made the connection as to how those interplay with each other using the matrix that you have there.

The fourth chart (figure 4) indicates the entire budget history of the Office of Commercial Programs. The fiscal year 1985 budget was a reprogramming action that was taken by NASA when the Office was formed, since we were not in place when the budget was submitted to the Congress.

Budget Summary

[Real year dollars in millions]

Program	Fiscal year 1985	Fiscal year 1986	Fiscal year 1987
Commercial use of space	7.6	[1]17.6 [16.2]	32.0
Technology utilization	9.5	[1]11.1 [10.6]	313.3
Total	17.1	[1]28.1 [26.8]	45.3

[1] Adjusted for Gramm-Rudman-Hollings measure

FIGURE 4

The first budget that we submitted to the Congress was the 1986 budget. I would like to remind the subcommittee that that request was for about $30 million, and that becomes important when we talk about the impact of the *Challenger* accident. The impact of Gramm-Rudman is indicated in the brackets next to 1986, and the 1987 column represents the request of the Office of Commercial Programs for 1987.

Senator GORTON. Let me interrupt with just one question at this point. In every respect when we go through fiscal year 1987, is that a current request reviewed in light of the loss of the *Challenger*?

Mr. GILLAM. In this case it is, sir. In the case of the Office of Commercial Programs' mission, that is the current request in light of the *Challenger* accident.

Senator GORTON. Go ahead.

Mr. GILLAM. I will give you a little bit of amplification on that. I may as well do it now. Our 1986 request and the appropriation that we received for 1986 caused us to stretch out and delay our program. So we went back and did a bottoms-up reconstruction of our program, because our 1986 program was reduced.

That stretchout in the program and the stretchout of our activities would have delayed our flight activities until late fiscal 1987 and early fiscal 1988. The loss of the *Challenger* now coincides, and the planned resumption of flight activities coincides, with when our projects would have been ready to fly because we were delayed for budget reasons.

Senator GORTON. Let me interrupt with just one more question. Are those figures based on the announced attempt to recommence flight activities about 1 year after the loss of the *Challenger*, with nine taking place in the first year?

Mr. GILLAM. No, sir. Those figures are based on the availability of the flight hardware that we were developing that would fly research and experimental activity on *Challenger*. That flight hardware was delayed because we could not initiate it in 1986 because of the budget reductions.

We then initiated—maybe I am misunderstanding the question.

Senator GORTON. I think you misunderstand the thrust of my question. Does the $32 million requested for fiscal year 1987 for Commercial use of Space assume that the space shuttle will be again flying in roughly February 1987, and that there will be nine missions in the first year after it flies?

Mr. GILLAM. No, sir, it does not.

Senator GORTON. It will be this amount of money even though there could be another 6-month delay in flying, and even though there may be fewer missions?

Mr. GILLAM. Yes, sir.

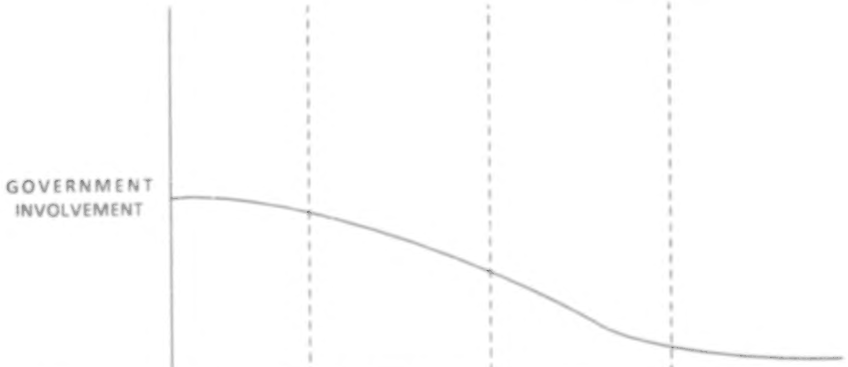
Senator HOLLINGS. What is the assumption, Mr. Gillam? When do you commence in your mind with this analysis, when do you commence flight?

Mr. GILLAM. Our budget is geared to the availability of the hardware that we are funding to fly. That availability of hardware begins in late 1987, early 1988. So if *Challenger* did not fly until 1988, then that would match our hardware availability as submitted in this budget.

Senator GORTON. Thank you.

Mr. GILLAM. The next chart (figure 5) is to give an overview of our agreements activity over the life of the commercial program. Down in the lower bottom of the chart where it says "agreement type," I would like to explain what some of those mean.

COMMERCIAL PROGRAM LIFE



STAGE	RESEARCH	CONCEPTUAL DEVELOPMENT	PROTOTYPE	COMMERCIAL OPERATIONS	
AGREEMENT TYPE	TEA/IGI/JEA	JEA		SSDA	LSA

FIGURE 5

The IGI is an industrial guest investigator agreement, where industry provides a member of the experiment team. The experiment is a NASA experiment. Industry provides a member of the team so that he can look at, observe, participate, make comments on the conduct of an experiment. That's the lowest level of industry involvement that we can have.

The TEA is the technical exchange agreement, wherein industry is interested in experimentation, and they use NASA ground test facilities and NASA aircraft, such as the KC-135, to do preliminary experimental work prior to developing an experiment to fly in space.

The joint endeavor agreement is an agreement to fly an experiment in space for either basic research purposes, for conceptual development purposes, or as prototypes for commercial endeavors, as indicated on the bottom of the chart.

As we graduate from the prototype commercial endeavor activity, the first of a kind of a new application in space is given an agreement that we call a space systems development agreement, which is the SSDA. That is the standard launch services agreement that allows them to pay for the flight after the flight occurs out of their commercial revenues that they are deriving from their commercial endeavor.

After that, they have the standard launch services agreement where they pay before the launch. And this is the conceptual framework in which our agreements structure is conceived.

The next chart (figure 6) outlines the outreach activities that we have implemented in the first 12 months of our program office life. We have received quite a bit in the way of recommendations from the Vanderslice committee of the NASA Advisory Council as to how we might improve these outreach activities. We are in the process of implementing those, but these are the highlights of what is going on with respect to our outreach activities. I will not go over them item by item.

OUTREACH ACTIVITIES

Field Centers: Publish facilities brochures; publish techncial outreach information; conduct technical presentations.

Corporate Associates Program: AIAA contacts Fortune 500 non-aerospace companies to establish idea exchange; Contacts included Deere, 3M, DuPont.

Headquaters Outreach: Fund and monitor field centers; Contract for outreach in chemical and auto industries.

Consolidated User Development: User development under one contract; RFP available in April 1986; contract award fourth quarter 1986.

FIGURE 6

The next chart (figure 7) talks about something that does not appear in the NASA budget, and we present that in the way of information, and that is the Small Business Innovation Research Program. As you know, that program is derived from the Small Business Innovation Development Act of 1982. It was approved in July 1982. It has sunset provisions as indicated on the chart.

SMALL BUSINESS INNOVATION RESEARCH LEGISLATED FEATURES

"Small Business Innovation Development Act of 1982," P.L. 97-219: Approved, July 22, 1982; Effective, October 1, 1982; "Sunset", October 1, 1988.

Requires expenditure of not less than specified percentage of extramural research and development budget.

	Fiscal Year			
	1983	1984	1985	1986
NASA (percent)	0.2	0.6	1.0	1.25
NASA (dollars in millions)	4.945	13.229	24.2	32.6

Requires solicitation of proposals from small business (less than 500 employees).

FIGURE 7

The act requires that a certain percentage of the NASA extramural R&D budget be spent on this program, and the figures that are indicated there are the legislated percentages. And the numbers indicated below is what that translates to in terms of dollars in the program. There is not a budget line item for this. It is sort of a tax that is placed on the R&D program as indicated in the bill.

Senator GORTON. Have you been meeting those goals?

Mr. GILLAM. Yes, we have, through fiscal year 1986. The numbers are the GRH, post-GRH—Gramm-Rudman-Hollings—numbers, and we would expect that number to be about $26 million.

It is a three-phase program. The phases are indicated in the legislation. Fiscal 1986 is the first year that we are beginning to have graduates from the program, and we are beginning to get some outstanding results from that program. And as we have graduates, we would like to come up and make a presentation to you and members of the subcommittee on the types of things that are being accomplished through that program.

The last two charts (figures 8 and 9) are simply highlights of our program activities over the last 18 months or so of the life of the program office. In 1986 we funded—I'm sorry. 1985 we funded five Centers for the Commercial Development of Space. We have a solicitation on the streets that closes April 15, next week, for additional centers for commercial development.

HIGHLIGHTS

COMMERCIAL DEVELOPMENT

CCDS—5 funded in 1985, solicitation out for 5-7 in 1986.

Generic flight equipment—started procurement of materials processing furnaces, refirgerators, and infrastructure.

Technical data base—adding data through flight agreements and CCDS.

Agreements—12 major agreements in force, processing about 2 dozen more.

SMALL BUSINESS INNOVATION RESEARCH

Accomplished in 3 Phase I and 2 Phase II cycles: 3060 proposals, 381 Phase I and 129 Phase II awards. More than 110 aeronautics and space technology areas funded 250 small businesses in 8 Field Centers' programs 12% of funds to minority and disadvantaged high-tech firms

FIGURE 8

HIGHLIGHTS

TECHNOLOGY UTILIZATION

Dissemination: Established pilot technology transfer program with the FLC - far west region (8 states), Formalized links with state-sponsored economic development programs (8states); and 28% circulation growth in commercial NASA Tech Briefs Journal.

Applications: PIMS approved for human trials by FDA; Automatic implantable defibrillator authorized for commercial sales by FDA; Aquaculture treatment techniques installed in 4 cities; and Ultrasonic residual stress monitor to measure metal stress has been commercialized.

FIGURE 9

We have letters of intent from approximately 45 proposers who will be in the 1986 round of competition. We would expect to have those awards early this summer. We are procuring the flight equipment that I mentioned to you. The schedule of the flight equipment is why we are not as impacted by the *Challenger* accident as other activities within NASA.

We are working on expanding the NASA technical data base so that the private sector can have access to that data, so that they can use it for commercial purposes. We have in effect 12 major agreements, and by major agreements our categorization here is agreements for flight experiments.

If you take all of the IGI's, TEA's, and JEA's and MOU's and other types of agreements, we have approved currently approximately 65 agreements between NASA and the private sector.

The Small Business Innovation Research Program highlights, I will not go into those in detail, but they are available. That talks about the number of proposals that we received in that program, and to date through fiscal year 1985 we have received 3,060 proposals in that program.

In the Technology Utilization Program, we are reinvigorating that program. We have several pilot activities underway that are mentioned in the detailed statement, Mr. Chairman. In our applications program, we have several items indicated there, and I would like to take the time to go over those because they are written in NASA-ese. The "PIMS" is the programmable implantable medication device that periodically dispenses certain dosages of medicine that are required for people such as diabetics needing insulin.

The automatic implantable defibrillator is a device that is like a pacemaker for heart victims. It assists in defibrillating the heart at the onset of ventricular fibrillation.

The aquaculture treatment is a process that has been developed at the National Space Technology Laboratory using underwater plants for purification of water.

And finally, the ultrasonic residual stress monitor is a mechanism that has been used extensively to date by the railroads in determining stress and other strain factors in rails. From what I understand on the news, it probably could have been used in Bowie yesterday.

That is an interpretation of the acronyms that are used in that applications section.

Thank you very much, Mr. Chairman and members of the subcommittee. I am ready to attempt to answer your questions.

Senator GORTON. Mr. Gillam, you have been presented with two separate setbacks since *Challenger* as the result of the suspension of shuttle flights. One simply is that there will be a significant number of flights which will not take place for the entire period of time until you recommence. The second is that, at least for an extended period of time, there will only be three orbiters after you start flying again.

How is space commercialization going to be affected by each of those setbacks, both the suspension of flights and future constrained launch capability? What happens to JEA customers who are already scheduled to fly? What kind of priority will they have? Will they be so far down the list that many of them will be unable to fly on a timely basis?

Mr. GILLAM. To answer your question, Mr. Chairman, that impact will be a twofold impact. Because there is an existing commercial market, that being the commercial communications satellite market, they will be impacted rather drastically by the fact that they cannot get their satellites up for an extended period of time without a definition of what that extended period of time may be.

In terms of the commercial development area, there are two, only two customers that will be, or users, that will be significantly impacted. Those are the McDonnell Douglas people, who were working to have a prototype of their electrophoresis factory flown the last part of 1986, and the 3M Corp., who also had some experiments that were scheduled to fly this year.

Those will be immediately impacted. Others of our joint endeavor agreement customers will be impacted by delays. However, these development people generally fly secondary payloads. They either fly in the middeck of the shuttle or they attach along the side or the structures across the bay, in the shuttle payload bay.

Senator GORTON. So they are not likely to be preempted by Defense Department priorities?

Mr. GILLAM. Not necessarily. It is possible that they may be, but it is also possible that they can fly along with Defense Department payloads.

Senator GORTON. What other priorities are there that are higher than JEA customers?

Mr. GILLAM. Well, in terms of secondary payload assignments, I do not believe that there are priorities that are higher. The NASA hierarchy, it has been publicly announced, is first, Department of Defense payloads, second, science payloads with a specific planetary window, third, other U.S. Government, foreign and domestic commercial payloads.

There are not a lot of NASA secondary payloads. There are a lot of NASA science missions that you could call the same kind of missions as the commercial development payloads that we are talking about.

However, we expect to be impacted more by the backlog of payloads that are not flying during the 12 month period and getting those flown, with those having priority. That is of greater concern than the other.

There is another impact. We are talking with a lot of companies about signing JEA's. They are saying "Since you are down for a year, we can wait a year to go into the process of working with you on a JEA." That is a problem that we also have to face: That they are delaying their decisions to go into space activities because of the hiatus.

I would say the last item that I mentioned is one that is of more concern than scheduling and scheduling priorities at the moment.

Senator GORTON. Can these customers use this down time constructively?

Mr. GILLAM. Would you repeat the question?

Senator GORTON. Can they use this down time constructively?

Mr. GILLAM. All of our people can, because they can, through the TEA and other processes, prepare their experiment more effectively using the airborne equipment, the KC-135 drop towers, drop tubes, and other items to ensure that the experiment that they are running will give them the desired results. But they can use the ground facilities and ground capabilities effectively, yes.

Senator GORTON. From the perspective of your office, should a replacement shuttle be built even if the costs would have to be absorbed within future NASA budgets which have only a minimal growth?

Mr. GILLAM. That is a tough question, Mr. Chairman, because a future orbiter might abolish my office, and it would be very difficult for me to answer a question that could have those kinds of implications. If it is going to be absorbed from the NASA budget the money is going to have to come from somewhere within the current levels, and that somewhere could do significant damage to the rest of NASA's programs.

So, I would be very hard pressed to answer a question like that without some knowledge of the consequences.

Senator GORTON. On another subject, what has delayed the signing of the agreement with General Dynamics to privatize the Atlas ELV, and when is it likely that such an agreement will be signed?

Mr. GILLAM. To answer the question in both parts, the delay has generally been caused—it is a difficult question to answer. The original delay was caused by NASA presenting to General Dynamics a proposed agreement and General Dynamics not responding for an extended period of time. They were operating at their pace.

It took us a great deal of time to get their response. And we finally negotiated an arrangement, and we worked out an agreement that we would hold on that arrangement, and not proceed. Ten days ago we received a call from General Dynamics requesting, we are now ready to proceed. We would expect that that agreement would be concluded within the next few weeks.

We will submit that agreement to the Congress in the same manner that we did the transspace carrier agreement. That is submitted with the understanding that the Congress would respond in 30 days, and so I would guess 2 weeks plus 30 days, we will be ready to sign the agreement with General Dynamics.

Senator GORTON. Do you believe that NASA should continue to launch commercial communications satellites with a three-orbiter fleet?

Mr. GILLAM. I can only give my personal opinion.

Senator GORTON. That is all right.

Mr. GILLAM. The answer is yes. I believe that NASA has made a commitment to certain commercial communications satellite customers through contracts and contractual arrangements, and I believe that we have to prove that we are a reliable partner by living up to the terms and conditions of those contracts to the best of our ability.

Senator GORTON. I have taken quite a bit of time. I do have more questions, but I have two colleagues here, and I would like to defer to them for a while.

Senator Hollings?

Senator HOLLINGS. Let me yield. I would ask that question right there. Can you be a reliable partner, Mr. Gillam, with the expendable launch vehicles? In other words, can you mix your fleet to consist of shuttles and also ELV's? Can you get back into that kind of a mix? Can you comply with your launch contracts and start with those ELV's? Did you propose $100 million in the NASA supplemental request to OMB in order to procure four ELV's. Is that right or wrong?

Mr. GILLAM. Not to my knowledge, sir.

Senator HOLLINGS. You do not know about that. Would you recommend that we do that in order to, as you just described it, continue as a reliable partner? You have got to have the shuttle in order to fill out those commercial launch contracts. Why not with expendable launch vehicles?

Mr. GILLAM. It is a difficult question to answer, Senator. It will take us a couple or 3 years to build an expendable launch vehicle. At the same time, it will take a couple or 3 years to build an orbiter. So the problem period is the 2 to 3 years that you have between now and the time that they start to come off the production line. So, you can't just fill in with expendable systems that are not built, and lead time on expendable vehicles, the last I saw the lead time on the Delta vehicle for manufacture, was something between 30 and 36 months, and for Atlas Centaur it was something over 40 months. You can't fill in the interim period with expendable vehicles that you do not have.

So the question is not something that you can just immediately transition into. The NASA position that has been stated is that NASA missions—I am sorry, civil missions that require expendable launch vehicles, those requirements will be met either by using the CELV's of the Department of Defense or private sector ELV's.

Senator HOLLINGS. Well, how about the four Deltas? Do you not have partially built, some Delta ELV's? I am wondering who the legal owner is, whether it is NASA, the DOD, or the Transspace carriers. Which of the three?

Mr. GILLAM. Senator, we have three vehicles that are partially built, Deltas 182, 183, and 184.

Senator HOLLINGS. What is the completion date of those three?

Mr. GILLAM. The information I have is that they can be completed, but within 24 months of go-ahead. That is, the first one comes out 24 months. The next one comes out a month or so after that. And the third one comes out a month or so after that. However, to the best of my knowledge, NASA currently has an agreement with the Department of Defense that that residual hardware that is in NASA's possession is turned over to the Department of Defense for their utilization, and if they do not utilize it, they will return it to NASA.

As of today they have not returned any of the residual hardware that exists over to NASA as excess to their requirements.

Senator HOLLINGS. Could that work the other way around? Could the Department of Defense in this particular emergency help you out so you could continue your commercial activities?

Mr. GILLAM. If they happen to have no spare hardware that they have no intent to use, I would presume it would work the other way around.

Senator HOLLINGS. Have you contacted them? Do you have any idea? That is what the committee is anxious to find out. We are anxious, like you, to play catchup ball. What do we do? Do we ask the Department of Defense if they can help us?

Mr. GILLAM. I do not know, Senator. I do not have any knowledge of that having been done.

Senator HOLLINGS. And who owns those three Delta ELV's?

Mr. GILLAM. They were bought by NASA. NASA holds title to the vehicles. But DOD has first shot at them, if you will, sir.

Senator HOLLINGS. I see. What incentives do you have to facilitate commercial space activities?

Mr. GILLAM. Several. The joint agreement is one of the major ones. The other major incentive that we have is the Centers for the Commercial Development of Space Program. Those are two major activities that we have initiated in our first 18 months of the office operation, to try to stimulate private sector involvement.

In addition to that, we are using portions of the Small Business Innovation Research Program, and we are using the NASA Technology Utilization Program to stimulate private involvement. The major difference between Technology Utilization and Commercial Development is, we are trying to transfer off-the-shelf technology that has already been developed by NASA in the Technology Utilization Program, and in the Commercial Development Program we are trying to develop new technology and new knowledge.

Senator HOLLINGS. Well, are you considering other policy changes that would facilitate commercial space activities, such as the termination liability or guaranteed buys of the services?

Mr. GILLAM. We have not reached that stage yet, but we would be willing to do so. In terms of future space activity, the space station has put out guidelines for commercial involvement, private sector ownership of elements of the space station, and they are leading the pack in that regard. They have not reached the stage where they need to make a policy determination on something such as termination liability or guaranteed markets, but that is something that is a little further downstream.

Senator HOLLINGS, Well, a good example, I thought or have been told was the Leasecraft Platform. To make it commercially feasible, NASA only had to provide to Fairchild termination liability, that would have facilitated it. Why was NASA reluctant to do that?

Mr. GILLAM. I do not have the details on that program. That was a procurement action that was taken in the Space Science and Applications Program, which is coming on right after me. I am sure they would be able to provide you with details on that. However, with respect to that program, I would like to just state some opinions not officially of the Office of Commercial Programs.

It seems to me from what I have heard about the program, and I am operating on hearsay, that the Government was the major purchaser, and I am not sure that where the Government is the major purchaser of a service, that that really fits into the area of commercialization.

Senator HOLLINGS. So you separate out where the Government is the purchaser.

Mr. GILLAM. Where the Government is the major customer, I am not sure that fits into our notion of commercialization. Where the Government is the major buyer of the services, that could be construed as another mechanism for Government contracting rather than commercialization.

Senator HOLLINGS. And where would my Government go other than to your office? Where would my Government go other than to your office for those services? You are not going over to the Department of Defense.

Mr. GILLAM. I mean the Government purchasing from the private sector. Services that the Government needs is not really the commercialization of space, because we have been doing that throughout the space program.

Senator HOLLINGS. Elaborate, then I will yield. With respect to all three of us on the Budget Committee, we are being charged to look at the program, unfortunately, the program has been sort of closed down. You indicate you cannot get anything up for a couple of years and everything else, and we want to go, go, go. We cannot let the talent like the Mr. Gillams leave. But there ought to be some savings, they say, since we do not have the program going. There should be some savings in cost. I do not see that in this budget request at all, and I just want to hear your general comment with respect to savings as a result of not going forward with commercial endeavors that we have for NASA.

Mr. GILLAM. What I would like to indicate is that we are going forward. The Centers for Commercial Development of Space, we have that program going. It is under way. We are going to select between five and seven in 1986 and additional ones in 1987. These in turn will generate research activity that will generate flight experiments for the shuttle that we will see in the 1988, 1989, and 1990 timeframe.

The program is proceeding even though there has been an impact on both the agency and its activities from the accident. I would have to say that our 1986 submission to the Congress and the resulting 1986 program shows a substantial savings. We requested $30 million for commercial development of space in 1986, and $11.1 million for technology utilization. The program was squeezed pretty hard in the first year that we submitted a budget request, and it is difficult to get savings out of a program that has already been squeezed.

Senator HOLLINGS. You are ready to use more money?

Mr. GILLAM. No, sir, if I had been, I would have asked for more, sir.

Senator HOLLINGS. Well, you just said you asked for more. All right. Thank you a lot.

Senator GORTON. Senator Riegle.

Mr. GILLAM. Not more than we requested, sir.

Senator RIEGLE. Let me ask you where you think we stand right now with respect to foreign competition as a result of this accident on the commercialization side of things.

Mr. GILLAM. That is a fairly broad question. On the commercialization side of things, the commercial transportation aspects of the United States, commercial ELV's, commercial participation in shuttle has not had an opportunity to evolve to the point that it can fill the void created as a result of the accident, and my understanding from conversations that I have had with the private sector world is that they are looking to alternatives such as Ariane, maybe the Japanese, maybe even the Chinese.

In that sense, it has had an impact in terms of the commercial communications satellite community. They are at a loss at the moment.

Senator RIEGLE. How serious is that problem, in your view, from a national point of view? I mean, as we think about it from the strategic interest of the United States to be out of the game and to have foreign competitors in the game and now have sort of complete access to what business there is there, what are the implications of this for the country?

Mr. GILLAM. I think the implications could be quite serious, but I have not had the opportunity to study the matter to the point that I could give you a definitive answer that I believe, A, B, C. I can only say that it is frightening.

Senator RIEGLE. Well, you must have some way to give us a sense as to what foreign competitors are doing. I mean, how are they responding to this awkward time that we are in here where we are basically out of business? What are they doing, and what does this mean for the future?

Mr. GILLAM. I think they are responding in terms of the transportation item, and what I have said in the transportation context. I think they are responding just as we would. They are trying to take advantage of the situation, to bolster their own posture.

In the other areas of commercial use of space, the Japanese are forming a formidable program similar to the program that they formed in the microelectronics world. The Germans have quite a formidable program of commercial development under way, and ESA, through items like the Eureka, also are playing very heavily in the game. And I think that it is going to become quite a competitive arena.

Senator RIEGLE. I would think that that would be one of the very strongest arguments that you would have in coming here today, would be what this international competitive situation now looks like because of this change in circumstance. And I am wondering who in your shop is the expert on this. Is anybody really tracking this that could give us a definitive answer as to what we face in the way of an international competitive challenge here, or something that causes you a sense of alarm? Who can tell us more about that?

Mr. GILLAM. The NASA Office of International Affairs is the source for the information that we have on what is going on in those arenas. Basically we try to keep up with what is going on in that area through that office and through briefings from that office as well as briefings from the involved individuals from Japan, Germany, and other countries who are playing in the arena.

However, the focus of our activities is basically domestic, and so we do not have as much contact as we might if we were playing in that arena, but I would say the Office of International Affairs of NASA is probably the most qualified NASA organization to tell you what is going on in that arena.

Senator RIEGLE. It sounds to me like for the time being, though, that is your principal problem, isn't it? I mean, you are out of business, and they are in business.

Mr. GILLAM. In a way. In commercial development, in developing new commercial uses of space, they are out of business like we are, because the primary vehicle for accomplishing those types of endeavors is the space shuttle.

When you get away from the transportation arena, when you talk about materials processing in space, when you talk about developing space technology, the vehicle for doing that is the space shuttle, so in that sense they are in the same situation. The transportation situation and the communications situation are quite different.

Senator RIEGLE. I tend to be of the view that I would like to see a balanced space program as we go forward here and not have any particular component preempt the others, and yet as you have said and is widely known, the Defense Department under the list of priorities is going to have sort of first priority. I think a lot of things are going to get bumped aside as a result of that, particularly because we do not have any substitute machinery that we can have on line for some long period of time here. I would think that this is a signal to foreign competition and that this is a terrific opportunity for them, and I think they are smart enough to see it, and we are beginning to see articles to that effect.

There was a story in the New York Times—I am sure you have seen it—on April 4 entitled "U.S. Urged to Press Space Drive to Pace Foreign Competition." Have you seen that piece? I do not want to refer to it if you have not.

Mr. GILLAM. Yes, sir.

Senator Riegle. It suggests, you know, that the rest of the world is moving ahead here, and they have now even more of an incentive to move rapidly because we are not able to move at this time, and we are going to have this gap particularly, I am afraid, on the commercial side. So it seems to me that I would not see this as somebody else's job in NASA. I would see this really as your job, to understand this better.

I do not mean to just say that in a critical way, but I am somewhat surprised at the answer, and I am wondering if we are too disconnected. I mean, it sounds a little bit like the booster rocket problem. You know, that it is somebody else's department. I think you ought to be the person who ought to be able to speak quite knowingly as to what is going on in terms of foreign commercialization.

Mr. Gillam. I did not mean to imply that we were not interested in that or infer it. I thought the question was, Who in NASA is most expert in this field, and we do keep up with what they are doing through that office, through, as I said, discussions with the people who are actually involved.

They are quite ready to exchange information on how they are structuring, how they are going about what they are doing, and surprisingly, what the Germans are doing with Intospace and what the Japanese are doing with their organization, even though they are doing it with private sector organizations because they have private entities doing what the Office of Commercial Programs is doing within NASA. What we are doing is amazingly parallel.

And in discussions with them we find that they are having the same difficulty in convincing private companies to come and participate in space activities that we are having, so we are aware of what is going on. I answered the question in the sense of who is expert in NASA and what is going on in the foreign community.

Senator Riegle. Well, let me try to ask it a little different way, because I still want to understand this better. I start from the premise that I am concerned about foreign competition. Now, maybe you will tell me things that cause me to feel that I do not have to be quite so concerned about it. But to the extent that foreign competition is a problem for us here, and people are starting to move into the space arena that have not been in it before, and now they have a particular opportunity because we are handicapped here for a period of time, I guess what I would like to hear from you is your current assessment of what the competitive challenge looks like.

How would you, based on your knowledge and sense of it today, how would you describe that international challenge and competition that we are facing or are likely to face over the next 1, 2, 3 years?

Mr. Gillam. My assessment is that both the Germans and the Japanese are mounting formidable programs in the commercial exploitation of space. My assessment is that the current situation can be exploited in terms of commercial space transportation, and possibly commercial communications satellites.

However, the other areas, since they are dependent on the shuttle or a shuttle-type vehicle that can carry the processing experiments or the other experimentation that they are doing up and back. Their current ability to exploit the situation is limited to transportation and communications, but going along with communications you have ground stations which are a substantial amount of capital investment on the part of the community, so you are talking about a large economic block which they can try to exploit.

In the other areas, I am concerned about their competition because they are mounting formidable programs, in terms of materials processing in space, both the Germans and the Japanese and in terms of other areas of being in a posture to exploit their components of or their elements of the space station when it comes about. And their programs are quite large, and their programs are quite serious.

Senator RIEGLE. Is there anything that you have given us today that would fall into the description of being a response to that challenge, or is there anything more that you would like to say to us or suggest to us that might enable us to not only anticipate that problem, but to respond to it within our current condition?

Mr. GILLAM. Well, I would think that our program, what we are doing, is not formulated in response. It was formulated in anticipation of a challenge that we saw coming. Our program was formulated several months before the German Intospace group was formed or before the Japanese group was formed. And I would have to say at this stage of the game they are modeling what they are doing after what we are doing. So in that sense we briefly have a lead. We have to maintain that lead.

Senator RIEGLE. But post the accident, in light of the fact you put your plans together before that, is there anything more that we ought to be considering doing that would address or be related to this international competition problem?

Mr. GILLAM. I would have to think about that and supply that for the record if I could, Senator. We do have a distinct advantage in the sense that we offer joint agreements where U.S. domestic firms fly free. The Japanese and Germans, if they are going to fly their experiments on the shuttle other than in a cooperative scientific venture, have to pay. So that the Japanese are paying a substantive amount of funds for the spacelab mission that they have on a scheduled launch shuttle. It was scheduled for 1988 or earlier. I am not sure what the down time might mean. But we do have an advantage in terms of U.S. industry in that sense. What other things we might do is something I would have to think about.

[The following information was subsequently received for the record:]

We are beginning to see increased foreign competition in space-related research and development. I believe that the best resp[illegible]se we can make is to continue and increase our efforts to stimulate U.S. corporate investment and involvement in commercial space endeavors. The Office of Commercial Programs (OCP) is accomplishing this through various means. For example, NASA offers, at no cost, flights aboard the shuttle in exchange for certain data on experimental payloads with commercial potential. Many companies cannot afford the cost of equipment associated with space research. The OCP Research and Development Enhancement Program creates generic hardware and facilities which may be used by the private sector. Newly established Centers for the Commercial Development of Space are consortia of industry, academia, and Government. NASA assists with their inception and supports them for five years, after which they will be self-supporting. NASA hopes to combine the efforts of private companies and academic institutions to speed commercial application of space research.

Senator **Riegle**. Well, why do you not do that, and I would be interested in any suggestions you have. Now, if we find that in the order of things, with the delays and what have you, that commercial business gets pushed out of the launch schedule, or is basically reduced to a very minimal amount, would that not have the effect of helping the foreign competition, if you will? Would that not have the effect of pushing U.S. customers in that direction? Would it not have the effect of causing foreign suppliers to broaden their definition of what they tried to do?

In other words, if we are not able to accommodate the commercial businesses in this country, are they not likely to have to look elsewhere, and is that not likely to help foster a tougher kind of foreign competition in the future?

Mr. **Gillam**. Yes, sir, but if we can develop a viable commercial transportation system here in this country, then that system I am certain could meet that competition.

Senator **Riegle**. How long would we have to do that, though, if you are out of business. Let us say you are not able to handle much commercial business for the next 3 years.

Mr. **Gillam**. Right now is when we have to develop that capability, sir.

Senator **Riegle**. I do not see an answer for the gap, and it seems to me the gap puts us in a vulnerable position. I expect that we will be exploited during that period.

Mr. **Gillam**. Yes, sir.

Senator **Riegle**. I guess what I would like to hear is more about the nature of that threat, because part of the way I think you justify the expenditures we are going to have to make here is to be able to see that problem and articulate it and help us see it and help us be able to articulate it in a way that provides the commitment of resources to do something about meeting it.

This is a new condition, but I think it is all pretty hazy right now, and I think it would be valuable to try to make it clear, try to pin that down.

Mr. **Gillam**. Yes, sir.

Senator **Riegle**. Can you give the committee an indication of the concepts that are incorporated in the four private sector proposals to finance a replacement orbiter?

Mr. **Gillam**. The question is difficult. We went out with a request for expressions of interest. The respondents were only required to submit to us a letter that stated that they were interested. We are preparing a solicitation requesting more detail about a proposal that they would submit to us.

We have a letter from one proposer, General Space Corp., which outlines a concept. That concept entails their purchasing an orbiter and leasing that orbiter to the Government, if I remember correctly, "on favorable terms to the government."

That is too vague for us to be able to analytically determine whether or not it is a good proposal, but that is the closest that we come to a proposal.

The other three respondents have not given us either a concept or a proposal. They are waiting on us to send our solicitation out requesting proposals.

Senator RIEGLE. Do you have any written response from the other three at all?

Mr. GILLAM. We got the original letter. We have received since then letters expressing concern about newspaper articles which seemed to indicate to them that we have already chosen General Space as the chosen entity. We have then corresponded back to them, saying that that is not the case, that we do intend to come out with a request for proposals, and that they will have the opportunity to respond and propose at that time, sir.

Senator RIEGLE. Can you share with the committee copies of the letters you have received so far?

Mr. GILLAM. Yes, sir, we can provide those for the record.[1]

Senator RIEGLE. Can you give us a general sense? I realize that now you do not have this pinned down that specifically based on what you have just said, but does this approach, when you take into account rates of return on investment and tax factors and so forth, would the Government end up coming out in an advantageous position? Do you envision this working out financially or not?

Mr. GILLAM. That is one of our requirements, one that we published and we have submitted for the record, and we assume that the Congress has concurred.

Six fundamental criteria for private sector funding of an orbiter and an arrangement with NASA: One of those criteria is that the private sector must recognize that the Government has made a substantive investment in the Space Transportation System and should share in the benefits and the risk as well as the private sector sharing equitably in the benefits and the risk of any agreement that we might work out.

The difficulties that we have had in the past with proposals is that the proposal contains no risk on the part of the private sector, and the Government assumed all of the risk.

Senator RIEGLE. Now, would these companies as they respond to your more formal requests to them or opportunity for them to come back, if it is on the presumption that NASA is not going to be launching commercial or foreign payloads on the shuttle, would this not have the effect of changing their thinking about it? How are you going to handle that aspect?

Mr. GILLAM. That would have the effect of pulling them out of the game if they did not have an opportunity for a return on their investment, sir.

Senator RIEGLE. So you would envision, in fact, that if we were to go down that road at least that particular shuttle would be carrying a mix of business other than just U.S. Government business?

Mr. GILLAM. Yes, sir.

Senator RIEGLE. So specifically commercial and foreign payloads would be a component of what that Shuttle would carry?

Mr. GILLAM. All of the proposals that I have seen from the private sector to date and all of the ideas that I have heard in discussions with the private sector have seemed to indicate that they would expect to derive their return of investment from the commercial and foreign market as they exist today, sir.

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[1] The letters were retained in the committee files.

Senator RIEGLE. That is not at odds with your thinking?

Mr. GILLAM. No, sir, it is not.

Senator RIEGLE. Let me just cover quickly one more area so I do not overuse my time here.

In the aftermath to the accident, there are many rumors about the policy options being considered by the SIG space group, standing for senior interagency group on space, which is under the National Security Council, for those who do not know it and also for the stenographer who I am sure is struggling to keep up with these things.

Can you tell us what your role is, if any, in this process?

Mr. GILLAM. Yes, sir, I can. I have no role in the process. When I am asked for support by the NASA members I provide that support to the NASA members. When I am asked by the NASA participants in that process for information or data, I provide them that, but I have no direct role in the process.

Senator RIEGLE. So you would have no information as to what they are doing other than hearsay?

Mr. GILLAM. I have very little hearsay, sir.

Senator RIEGLE. OK. I will reserve my additional questions.

Senator GORTON. Senator Rockefeller.

Senator, you have no questions?

[Nods in the negative.]

Senator GORTON. We have several more witnesses. I have several additional questions, Senator Riegle. Shall we go on, or shall I submit them?

Senator RIEGLE. I am thinking maybe you should submit them, Mr. Chairman, just because we are likely to get interrupted by votes.

I also know that Senator Lautenberg is here.

Senator GORTON. OK. Without objection then, I have additional questions for the record. As you can tell, Mr. Gillam, we have great interest in what you are doing, and we would appreciate your prompt response to the additional questions which we will submit to you, and we thank you for coming today and for your candor.

Mr. GILLAM. Thank you, Mr. Chairman.

[The statement and questions and answers follow:]

Statement of

Isaac T. Gillam IV
Assistant Administrator
Office of Commercial Programs
National Aeronautics and Space Administration

Mr. Chairman and Distinguished Members of the Subcommittee:

We welcome this opportunity to testify on the fiscal year 1987 budget request. The Office of Commercial Programs' (OCP) request for $45.3 million will support commercial use of space programs at $32 million and technology utilization programs at $13.3 million. Over the past year, OCP has made significant progress in encouraging private sector investment in commercial space research and development and in promoting secondary application of NASA developed technology. This year we expect to see marked expansion of industrial involvement in commercial space activity.

Through its programs, OCP is creating foundations for emerging major commercial enterprises in space. Our charter is to encourage, stimulate, and assist with their establishment and expansion. In considering space as an alternative to Earth-based investment, the private sector must be assured of consistent and supportive Government actions relative to the development of space industry. We are working with other NASA offices to incorporate requirements of the private sector in the design of new programs and facilities. The Space Station Program, in particular, holds great promise for commercial activity in space. A Space Station Commercial Advocacy Group (CAG) has been formed and interacts with potential commercial users and entrepreneurs who are considering providing space products and services to the Space Station. Proposed NASA guidelines for U.S. commercial enterprises have also been released to industry for comment and we expect to finalize those guidelines later this spring. As an ongoing activity, we are examining legal and procedural regimes relative to commercial development, removing impediments wherever possible, as well as reviewing and developing policy to meet needs of the private sector. The following comments detail how OCP carries out its charter through its various programs. Following that, the statement briefly outlines the status of current efforts to privatize certain space activities and the effects of both the current budgetary situation and the Challenger loss.

COMMERCIAL DEVELOPMENT

Through the Commercial Use of Space Program, OCP increases private sector awareness of space opportunities and encourages increased industry investment and participation in high technology, space-based product and process research and development. OCP activities support commercially-oriented interests which differentiates them from other NASA programs. One key element of this program is the Centers for the Commercial Development of Space (CCDS).

CENTERS FOR THE COMMERCIAL DEVELOPMENT OF SPACE

The CCDS's are not-for-profit consortia which represent joint undertakings involving U.S. companies, academia, and non-NASA Government. The CCDS's are expected to stimulate high technology space-related research which will lead to the development of new products and processes having either commercial potential or contributing to new commercial ventures. In FY 1985, the first five grants for CCDS's were awarded by NASA. The second round of competition will occur this year with proposals due by April 15, 1986. Forty-five letters of intent to propose have been received so far. OCP plans on funding between five and seven Centers this round. In 1987, a third round of CCDS's will be chosen, completing the Center selections at a possible total of 18.

NASA supports the CCDS's by providing partial initial funding to continue for 5 years. Funding on a year-to-year basis will depend on the favorable annual review of progress in stimulating commercial ventures in space. We anticipate that NASA support will be between $750,000 and $1 million per year for each CCDS. A critical criterion in establishing a CCDS is maximizing the leverage of NASA funds with a high percentage of industry, university, and other institutional resources. These resources should substantially increase over a 5-year period until each CCDS is self-supporting.

RESEARCH AND DEVELOPMENT ENHANCEMENTS

Another key element of OCP's program to increase industry participation in space-based research and development focuses on encouraging U.S. industry use of NASA ground- and space-based facilities to support commercial space R&D for new products and processes. Through this activity, NASA hopes to reduce the financial risk of space ventures to a level somewhat equivalent to more traditional ground-based opportunities.

The following projects represent typical NASA-supported R&D enhancements to date. NASA funds these projects only after several industrial firms' interest and support for each project has been confirmed.

The Commercial Microgravity Research Augmentation Project will expand the Lewis Research Center Microgravity Materials Science Laboratories (currently supported by both the Office of Commercial Programs and the Office of Space Science and Applications) to provide functional duplicates of existing flight-qualified apparatus and advanced experimental equipment and instrumentation related to reduced gravity processes in glasses, ceramics, and polymers. This equipment will be made readily accessible to qualified industry/university groups to facilitate microgravity-related materials research activities.

The Protein Crystal Growth (PCG) System Project is designed to produce a large number of protein crystals in low-gravity of sufficient quality and size to permit molecular structure characterization by x-ray crystallography or neutron diffraction. Growth of such crystals is a crucial step in drug design, enzyme engineering, molecular computing development, and bio-chip technology. The successful growth of protein crystals requires relatively stable temperatures. In light of this fact, we are supporting PCG research by building four space flight-qualified refrigerator modules which will be available for use on the STS.

The Multiple Experiment Processing Furnace (MEPF) is a furnace that will accommodate investigations on technological phenomena involved in solidification of metals and semiconductor materials. The MEPF will be capable of processing a large number of samples on each mission and will have the capability for on-orbit change-out of samples.

Middeck Payload Accommodation Improvements. The backlog of middeck payloads is increasing while available space in middeck lockers for payloads has decreased due to the greater number of crew members now being flown and the loss of Challenger. This project was initiated in FY 1985 to build a rack which replaces the galley and will provide an additional stowage volume of 10 to 15 cubic feet for up to 400 pounds of payload. The Middeck Galley Rack will be used to support currently planned FY 1987 industrial payloads flown under Joint Endeavor Agreements (JEA).

Some of the other projects we plan to initiate in 1986 include: Chemical Vapor Deposition (CVD) Flow Characterization Facility, a commercial Long Duration Exposure Facility, and a Molecular Wake Shield Facility (MWSF). The latter facility uses an orbiting spacecraft to produce a high vacuum zone in its wake.

The following are planned R&D enhancements ongoing or to be initiated in FY 1987:

o A Centrifugal Motion Device (CMD) which can vary the "g" levels experienced by flight experiments from 10^{-2}g to about 10^{-6}g. This has significance for experiments which are being conducted to better understand the effect of gravity on terrestrial processes such as combustion.

o Laser furnace to provide a much more effective and efficient heating source.

o Ultrahigh temperature furnace for heating a wider variety of samples.

o Cargo bay carrier modifications to provide power and cooling beyond that currently in existence.

- o Organic and Polymer Crystal Growth System (OPCGS) to study the growth of low temperature crystal systems.

- o Quasi-Containerless Processing Facility (QCPF) which will use molten floating zones to produce high quality crystals and/or glasses.

- o Multiple Experiment Processing Furnace follow-on, and the

- o Protein Crystal Growth follow-on are projects we will initiate using the knowledge we gain from the construction and use of the current models.

- o Recirculating Isoelectric Focusing Device (RIFD) is a system similar to the continuous flow electrophoresis system (CFES) but uses a pH gradient to separate and purify biological materials.

AGREEMENTS

NASA actively encourages the commercial use of space through various agreements which induce the U.S. private sector to make significant capital investments in commercial space-related ventures. The Joint Endeavor Agreement and other types of agreements between NASA and U.S. private entities are the instruments through which OCP attempts to mitigate the private sector's extraordinary upfront technical and financial risks associated with these capital investment projects.

The agreements characteristically offer transportation on the Shuttle for the purposes of flying experiments in low gravity, as well as the use of other NASA facilities, equipment, and services. NASA makes this offer primarily in exchange for a sharing of research data and the private entity's good faith commitment to make commercial use of any resulting promising technology.

Commercial space ventures by new as well as established private entities in both the nonaerospace and aerospace sectors continue to increase significantly. OCP has 12 major agreements in force and we are evaluating and/or negotiating about two dozen proposals or concepts for proposals.

Our newest instrument, the Space System Development Agreement (SSDA), previously known as Modified Launch Services Agreement, has attracted significant private sector interest. A deferred payment provision for launch services, which can have many variations, is the primary characteristic of the SSDA. We signed our first SSDA in August 1985 with Space Industries, Inc., a small Houston-based firm that will construct and operate the first man-tended commercial platform in space. We signed our second SSDA in November 1985 with the Geostar Corporation. Geostar will primarily provide commercial position determination services.

Decreasing NASA's evaluation time for the proposed agreements remains a high priority. NASA fully recognizes the time sensitivities of the private sector. Accordingly, we are continuing our efforts to expedite NASA's evaluation of these agreements by revising our agreement review and processing procedure. We intend, through these revisions, to ensure that issues arising out of NASA's review of a proposed agreement are quickly resolved. Further, we are continuing efforts to establish shorter review deadlines, standardize several JEA articles, and increase the number of personnel assigned.

USER DEVELOPMENT

One of the goals of OCP is to stimulate new commercial ventures apart from direct NASA funding. To accomplish this goal in the long term, OCP is developing an outreach effort and expanding the technical data base.

The NASA Advisory Council Task Force on the Commercial Use of Space defines outreach as "...those steps necessary to identify and develop working partnerships with firms and academia that would enable them to assess whether or not there are profitable product opportunities for them." The Task Force recommends that, in addition to our in-house efforts, NASA contract for outreach assistance. A Request for Proposal (RFP) for a consolidated user development contract should be published in April and we plan to award the contract near the end of the fiscal year. The majority of OCP's user development efforts will be performed through this contract.

In order to encourage private sector involvement and investment in commercially-oriented microgravity processing -- widely accepted as the commercial space field with the most potential -- OCP is expanding the technical data base tailored to industrial users. Existing data bases are not comprehensive nor focused to the needs of industry and, therefore, inadequate to stimulate corporate investment in commercial space ventures. OCP is currently working to define such a data base and a preliminary cost estimate.

TECHNOLOGY UTILIZATION

NASA's Technology Utilization Program enhances the national economy and industrial productivity through transferring aerospace technology from NASA's R&D programs to nonaerospace sectors of the U.S. economy. Technology utilization is a means to establish new relationships with the private sector to create awareness of NASA's activities and stimulate greater commercial investment in space-related activities.

TECHNOLOGY DISSEMINATION

NASA's network of university-based Industrial Applications Centers (IAC) are the key component of the technology utilization information dissemination system. Their computerized access to technical information has stimulated significant corporate interest in Government-funded or -derived advanced technologies. During the past year, IAC's strengthened relationships with State-sponsored institutions, universities, and Federal laboratories, thus expanding their capacity to assist industrial entities.

Technology Utilization began an experimental effort with the Federal Laboratory Consortium (FLC). The NASA IAC at the University of Southern California and the FLC Far West Region have shared information to provide U.S. industry broader and more direct access to Government-generated technologies. This has been a productive endeavor and our FY 1987 activities include plans for linking the IAC's with the over 300 Federal laboratories nationwide. This will significantly increase and accelerate transfer and use of these new technologies. In turn, we expect that the commercialization of Government technology will be enhanced, improving productivity and creating a stronger U.S. industrial base.

Over the past few years, most States have initiated or expanded science and technology programs in conjunction with their industrial development objectives. These activities offer new opportunities for NASA to engage in cooperative relationships to stimulate economic growth through technology transfer. In FY 1987, OCP will focus technology dissemination efforts on State-supported economic development programs to serve broader industrial markets with particular emphasis on small and medium-sized businesses. To help this take effect, we have initiated discussions with the Small Business Administration in hopes of strengthening linkages and assistance arrangements between NASA's IAC's and the more than 400 Small Business Development Centers and subcenters throughout the Nation. Additionally, renewed emphasis and new relationships with the Council of State Governments and Public Technology, Incorporated, are in our planning for the coming year.

Commercial publication of the **NASA Tech Briefs** journal has proven to be a rewarding venture. The quarterly circulation increased from 75,000 to approximately 100,000 in the past 10 months, enabling NASA technology to reach a broader range of industrial users than was previously possible. It is anticipated that the quarterly circulation of the **NASA Tech Briefs** journal will increase to over 175,000 by mid-1987.

TECHNOLOGY APPLICATIONS

Technology applications activities of OCP include approximately 50 applications projects from automation, electronics, bioengineering, and rehabilitation and materials technology. The following are a few examples of successful transfer applications:

o Programmable Implantable Medication System (PIMS) has been approved by the Food and Drug Administration (FDA) for human trials with morphine for cancer patients and insulin for diabetics. PIMS is a device which releases medication automatically as needed by the body. The technology was developed for the Mars Viking spacecraft which required miniaturized fluid control used for metering nutrients into soil samples.

o Automatic Implantable Defibrillator (AID) has now been authorized by the FDA for commercial sales. Heart attack victims often can be saved by electric shock defibrillation, but many who die from a fibrillation episode are away from a proper treatment facility. The AID can sense the onset of fibrillation and deliver a balanced electric pulse to restore the heart to a normal rhythm.

o Ultrasonic residual stress monitor is used in steel components to measure stress. There is no calibration standard for metal stress and this monitor has uses in a wide range of applications including railroads, bridges, and turbine disks. It was developed to measure wing stress on aircraft.

o Aquaculture treatment techniques to convert raw sewage to drinking water were successfully applied in a pilot project with State and local support in San Diego, California. This program was initiated with Space Station needs in mind.

OCP has initiated two experimental technology application programs with the private sector. Approximately 30 large companies are expected to participate in the Technology Affiliates Program, a program to assist companies with productivity and automation. A consortium of over 200 small and medium-sized high technology firms has expressed interest in the Product Development Program. This program was developed to stimulate commercial introduction of specific new products derived from NASA technology. Both programs are designed to augment planning, research and development resources of U.S. industry through a direct relationship between NASA and industry.

In FY 1987, special attention will be focused on bioengineering and rehabilitation applications which address problems of the handicapped, disabled, and the elderly. In addressing these problems, NASA is working with the Administration on Aging, National Institute on Aging, National Institute on Handicapped Research, and the Veterans Administration.

Projects include:

o Memory or wandering aid for the elderly, stroke victims, and Alzheimers patients.

o Hydrocephalus (water on the brain) shunt for relieving intracranial pressure.

o Intracranial pressure monitoring device for victims of head injury.

o Handicapped driver-assist device.

o Low vision aid program in conjunction with Wilmer Eye Institute and the Optical Society of America.

Continued technology applications projects in public safety, transportation, and the environment will accompany these areas of increased activity.

SMALL BUSINESS INNOVATION RESEARCH

Although the Small Business Innovation Research (SBIR) Program derives its funding as a percentage of R&D funding agencywide, not from a direct appropriation, I am taking the liberty of giving the Committee an update on its activities. Management responsibility for NASA's SBIR Program was assigned to OCP in 1985. SBIR Program objectives, complementing other OCP objectives, are to stimulate technological innovation in the small business community, assist NASA in achieving its R&D program objectives, increase private sector commercialization of innovations derived from Federal R&D, and encourage minority and disadvantaged participation in technological innovation.

Since NASA's SBIR Program was initiated in 1983, approximately 250 small high-technology firms have been selected for more than 500 contract awards. Their activities are integral parts of almost every area of NASA's R&D program. All SBIR projects are competitively selected from proposals received in response to our annual SBIR Program solicitations.

Both Phase I technical feasibility demonstration projects and Phase II follow-on activities for the most promising Phase I projects are selected for award each year. During FY 1986, NASA will award approximately 150 Phase I contracts deriving from our 1985 program solicitation. We also will choose at least 100 Phase I proposals for award based on our 1986 solicitation, with contract awards scheduled for early FY 1987. Also during FY 1986, we will award approximately 65 Phase II contracts based on 1984 program year Phase I projects. Finally, in 1986, we expect to select another group of approximately 65 Phase II proposals from the 1985 program year, to be funded in early FY 1987.

During 1986 and 1987, NASA and other agencies concerned with SBIR will, as required by law, assess the program's effect on Federal R&D programs. These assessments, and other considerations including perceived progress in meeting basic SBIR Program objectives, are expected to be major determining factors on the program's future. While it is too early to predict the outcome of these events, it is clear that many of the SBIR projects have already become valuable to NASA's total R&D program, and that the participation of many of the small, high technology businesses now in the program would not likely have occurred without the special stimulation provided by the SBIR Program.

REPLACEMENT OF LOST LAUNCH CAPABILITY

NASA received four responses to our Request for Expressions of Interest in private sector financing of a replacement orbiter. In addition, we also received a concept paper from General Space Corporation, which was elaborated upon by Mr. Rockwell in his testimony of March 19, 1986 to the House Subcommittee on Space Science and Applications. Since that time, we have formed a team to prepare a Request for Proposals, which we expect to have in draft by the end of May 1986.

Concerning the privatization of Expendable Launch Vehicles, in 1984 NASA had signed a preliminary agreement with Transpace Carriers, Incorporated (TCI), for privatization of the Delta launch vehicle. Five amendments, signed between April 1984 and November 1985, extended the deadline by which TCI had to meet certain requirements and during which TCI may exclusively market Delta launch services. Amendment No. 5 expired on February 28, 1986. TCI asked for a 2-month extension to April 30, 1986. NASA signed and transmitted to TCI a sixth amendment which would grant the extension. TCI has proposed an alternative Amendment No. 6 which we are assessing. However, under the terms of Amendment No. 5, TCI had to meet certain requirements by February 14, 1986. The documents which TCI submitted did not meet the requirements and we have corresponded with TCI, and met with them, concerning fulfillment of the requirements.

I would also like to give you a status report on our negotiations with General Dynamics Corporation on privatization of the Atlas/Centaur. General Dynamics signed a draft agreement this fall. We are currently reviewing this draft in the context of the current situation, prior to forwarding it to the Senate Committee on Commerce, Science, and Transportation and the House Committee on Science and Technology for 30 days' review in accord with Section 110 of Public Law 98-52.

IMPACT OF SHUTTLE LOSS

The short-term (i.e., up to 1 year from now) impact of the loss of Challenger will be a delay in the flight of some commercial experiments. The long-term impact on commercial flights will depend upon the frequency of flight opportunities afforded to JEA's, and the amount of space allocated to those payloads. The long-term effects would be minimized if a Shuttle flight rate of 10-15 flights per year is realized and one commercial flight opportunity per mission is available. This flight opportunity would consist of middeck space and/or a portion of the payload bay for commercial R&D payloads. A more definitive impact statement is impossible to make until the NASA recovery plan is established.

IMPACT OF GRAMM-RUDMAN-HOLLINGS LAW

The effect of the Gramm-Rudman-Hollings measure on OCP's FY 1986 budget is a reduction of $1.3 million, from $28.1 million to $26.8 million. The funding reduction required by the Balanced Budget and Emergency Deficit Control Act of 1985 will lower commercial use of space funding for FY 1986 by about $800,000, from $17.0 million to $16.2 million. It will affect the commercial development program by stretching out the funding of some R&D enhancement hardware. The impact on the overall program will be minor, that impact being a delay in the delivery of some lower priority hardware. The CCDS program will not be affected. Technology utilization funding for FY 1986 will be decreased by $500,000 bringing the $11.1 million budget to $10.6 million. The reduction of funds assigned to technology utilization will affect technology applications projects. It has caused a delay in funding new starts proposed for FY 1986 and the stretch out of some earlier approved projects at NASA field centers. Such actions may eventually result in cancellation of some commitments on these cooperative projects with public and private sector partners.

The Office of Commercial Programs is grateful for the support of this Committee and we look forward to a very productive and exciting FY 1987. I will be happy to answer any questions the Committee may have.

QUESTIONS OF SENATOR GORTON AND THE ANSWERS THERETO

Question: In the original agreement that NASA signed with Transpace Carriers, Inc. (TCI), TCI had access to three partially-built Deltas, along with long-lead hardware items for seven additional Deltas. As a result of the Shuttle accident, what is the disposition of the three partially-built Deltas and the long-lead hardware items for the other seven Deltas?

Will the three Deltas be used for SDI purposes or for off-loading payloads previously manifested aboard the Shuttle?

Answer In NASA's original agreement with TCI, TCI had access to the three partially completed Delta vehicles and long lead hardware items provided TCI met certain conditions as specified in the May 1984 "Preliminary Agreement on Delta Commercialization." TCI has not met any of those conditions. In November 1984, SDIO signed a Memorandum of Agreement with NASA which gives SDIO control of the Delta flight hardware inventory in support of SDIO mission requirements. Currently, NASA is investigating which items within this inventory may not be needed by SDIO, although SDIO continues to draw on this inventory as needed.

Various items of the three partially completed Delta vehicles (Deltas 182, 183, and 184) have been used to construct the several experiments required by SDIO. Other hardware items are needed as spares for the SDIO program through launch of the SDIO missions. To date, it is unclear whether either NASA or TCI may have access to any of the Delta flight hardware inventory.

Question: If NASA were to decide to utilize Delta or Atlas ELVs for some of its own payloads, how would this affect the marketing arrangements with TCI and General Dynamics?

Answer: Currently, NASA does not have executed agreements with either TCI or General Dynamics on commercialization of Delta or Atlas/Centaur vehicles, respectively. However, NASA is committed to continue seeking firm arrangements on the commercialization of those expendable launch vehicles. If NASA were to use Delta or Atlas ELV's for some of its own payloads, the goal would be to do so on a commercial basis with viable, competitive U. S. companies, avoiding any impact on the potential success of those businesses. Although NASA's use of ELV's is an option which cannot be overlooked in view of (a) the Challenger accident, (b) NASA's standing commitment to a number of STS customers, and (c) the current absence of firm agreements on commercialization of ELV's, NASA would seek to maximize commercial marketing opportunities of ELV private sector companies. The affect on marketing, however, would depend on a number of factors including the length of such use, the status of STS operations, and, more importantly, the viability of the commercial operator.

Question: I understand that the Agency's decision to suspend Shuttle marketing activities is being reconsidered. Are there logical reasons for NASA to quit launching commercial communications satellites aboard the Shuttle, and if so, what should be done about the customers that have signed agreements with NASA for these launch services?

Answer: There are two major parts to the marketing activities at NASA today. One part deals with primary payloads such as commercial communications satellites and the other deals with commercial R&D payloads such as those flown under Joint Endeavor Agreements (JEA).

The loss of the Challenger has created circumstances which are substantially different than those of the preaccident era and until we can commit to launch dates, we will not be marketing Shuttle flights. We clearly have a shortfall in the national launch capability in the near term. ELV's may help us meet the shortfall for payloads such as commercial communications satellites, which do not require the capabilities of the Shuttle. It would not be our intention to compete for future business should a viable, competitive ELV industry be established.

Where we have made contractual commitments for launch services, we intend to honor them and will fly the payload as soon as possible.

NASA's Shuttle marketing activities (outreach) for commercial R&D and Space Station customers have not been suspended. NASA released a Request for Proposal (RFP) to the commercial community on April 18, 1986, to encourage the private sector to conduct experiments in space, experiments that may lead to new commercial products.

Customers that have signed agreements for commercial R&D can be assured NASA will honor its commitment to provide launch services when flights resume.

Question: If it is determined that NASA should resume using ELVs for certain payloads, what would be the most logical approach to implement this decision -- should NASA manage the programs as it did in the past, or should NASA simply purchase from the private sector vehicles for certain identifiable payloads?

Answer: Currently, NASA does not have executed agreements with either TCI or General Dynamics on commercialization of Delta or Atlas/Centaur vehicles, respectively. However, NASA is committed to continue seeking firm arrangements on the commercialization of those expendable launch vehicles. If NASA were to use Delta or Atlas ELV's for some of its own payloads, the goal would be to do so on a commercial basis with viable, competitive U. S. companies, avoiding any impact on the potential success of those businesses. Although NASA's use of ELV's is an option which cannot be overlooked in view of (a) the Challenger accident, (b) NASA's standing commitment to a number of STS customers, and (c) the current absence of firm agreements on commercialization of ELV's, NASA would seek to maximize commercial marketing opportunities of ELV private sector companies. The affect on marketing, however, would depend on a number of factors including the length of such use, the status of STS operations, and, more importantly, the viability of the commercial operator.

Privately-Financed Shuttle

Question: Could you describe the concept behind General Space Corporation (GSC) privately financing a replacement Shuttle?

Answer: General Space Corporation outlined its concept for private financing of a Shuttle orbiter in hearings before the House Committee on Science and Technology Subcommittee on Space Science and Applications on March 19, 1986. In testimony, GSC presented the following concepts:

- Funds for the purchase of the orbiter will derive from a combination of private and public offerings of General Space Corporation equity and debentures. The exact amount for the purchase is to be determined.
- The assurance of General Space Corporation's ability to raise these funds is tied to a long-term lease agreement with NASA, wherein, over a period to be determined, NASA leases the replacement orbiter from General Space at lease rates favorable to the government.
- General Space has been advised by major investment banks that, with such a lease, it will be possible to raise the funds required from the private sector.
- NASA will assume responsibility for procurement, maintenance, and all ground and flight operations for the new orbiter as it has for all previous orbiters.
- In addition to its responsibilities as lessor, General Space will propose to organize and operate an aggressive market development effort designed to expand and encourage private sector application and use of the STS.
- It will be proposed that incentive payments will be made by NASA to General Space for the described marketing, subject to the success of the marketing activities. NASA and General Space will share in the incremental dollar gain from the commercial marketing activities."

Question: Does this concept spread the risks in a reasonable and acceptable manner?

If not, what were the problems in the way that they are spread?

Answer: The concept GSC briefly outlined in the hearings does not appear to include any risks to GSC. Any proposal seriously considered by NASA must have an appropriate sharing of the risks between the proposer and the United States Government. However, the GSC concept is simply that: a concept. It is not a detailed proposal amenable to risk analysis.

Question: I understand that the GSC concept calls for GSC to market the Shuttle for a fee.

Do you believe that someone other than NASA is better equipped to market the Shuttle, and if so, why?

Answer: The major advantage of a private sector marketing agent could be the ability of that agent to provide a focused non-Government marketing effort with the intent and expectation of increased Shuttle use. If the agent also has significant funds at risk which will need to be recovered through the marketing of Shuttle, his incentives will be very great.

Centers for the Commercial Development of Space

Question: What progress have the five "Centers for Commercial Development of Space" shown?

What criteria have been established to measure the progress of these Centers?

Answer: Two of the Centers for Commercial Development of Space (CCDS), the University of Alabama at Huntsville and the University of Alabama at Birmingham, had activities underway that predated their establishment as CCDS's. Their activities are progressing well and they are in the process of developing/fabricating experiments to be flown on the Shuttle. Vanderbilt University and Battelle Laboratories have developed a plan for their CCDS activities and are in the process of implementing their research projects. The Institute for Technology Development is in the process of staffing up and planning its activities.

At this time, the following criteria have been established to measure the progress of the CCDS's:

a. The degree to which a CCDS has fostered a corporate proposal to NASA for a JEA, MLSA, etc.

b. The degree to which a CCDS activity is private sector-directed.

c. The quality of the R&D activities (including publications, patents, and reports) and the need for space.

d. The degree to which non-NASA resources (especially from the private sector) are contributing to the CCDS.

e. The internal operation of the CCDS including amount spent on administrative expenses, communications between members, etc.

f. The number of signed private sector participants and the ability to attract new participants/resources.

Question: Has authority been established to terminate NASA support of, or to terminate any Center, if it does not make sufficient progress?

Answer: The program solicitation to establish the CCDS's states, "Funding on a year-to-year basis will depend on a favorable annual review of progress in stimulating commercial ventures in space." This is considered our authority to terminate.

Question: The plans of your office are to expand the number of Centers to approximately 18. How did you arrive at this number?

Will a constrained launch capability affect the number of Centers that it is feasible to support?

Answer: The number of CCDS's we ultimately plan to fund depends on the future budget for commercial use of space. Based on our FY 1987 submission to Congress, we projected a number of 18. The recent proposed reduction in our budget by the House Subcommittee on Science and Applications is causing us to reevaluate this number. It is unclear in a reduced budget environment how many additional ones we could support over the five currently in operation.

Interest in the CCDS program itself should remain strong as long as access to space experimentation is timely. Obviously, without access to space, there would be no reason to establish a CCDS. OCP is doing everything it can to assure that a proper portion of payload space is available for commercial experiments.

Question: What have you learned so far from the first five Centers that will alter the way in which you manage and select additional Centers?

Answer: Industry must support CCDS's with their own resources in order that the CCDS's be effectively driven by private sector needs. When industry commits its own resources, it will closely follow the operation and review the results to insure that the CCDS's meet industry objectives.

Joint Endeavor Agreements (JEA)

Question: I understand that over the past few months, there have been some changes to certain aspects of NASA's basic joint endeavor agreement -- changes that now may require JEA customers to pay for the service of integrating their payloads to the Shuttle and also pay for third party liability insurance.

Why were both of these changes made or considered, and what is their current status?

Do you believe that these changes have been sending signals to the private sector that will encourage space commercialization?

Answer: Under the policy approved by the agency in March 1986, no charge will be made for JEA standard and nonstandard services, the former services defined as those provided to all users for transportation into low earth orbit and the latter services defined as those, in addition to standard services, that are required for flight of a payload that has been designed to accommodate the existing standard NASA interface for a particular location. Thus, the JEA partner will not pay for the services required for flight. A charge will be made for other services requested by the customer where they can be reasonably provided by NASA. These services are called optional services and will be negotiated with the Field Center performing them. Payment will be made under a customer/Field Center agreement.

Regarding third-party liability insurance, the agency is considering indemnifying JEA customers during the time the secondary payload is attached to the Shuttle.

For both of these issues, the private sector has voiced its concern that any charges made to JEA customers or requirements for insurance would discourage their R&D efforts for commercialization. OCP is striving to keep JEA charges to a minimum. NASA cannot charge a fee for private sector research without severely curtailing private sector interest. If a charge were made, private experiments would begin to drop out of the space research program.

Space Station - Commercialization

Question: In November, NASA issued Guidelines for U.S. Commercial Enterprises for the Space Station, and, as I understand, these responses were due in January.

What was the nature of the industry response, and what is likely to evolve from this exercise?

Answer: As I understand from the Office of Space Station, industry response was very positive on the "Draft NASA Guidelines for U.S. Commercial Enterprises for Space Station Development and Operations." Of 32 companies responding, 30 submitted positive comments. The Office of Space Station hopes to issue final guidelines late this spring.

Question: In your opinion, what are the most logical candidates for commercial space endeavors aboard the space station?

Answer: The most logical endeavors include providing Space Station infrastructure, power, and services as well as performing commercial experimentation and operations on board the Station. Materials processing, remote sensing, and communications satellite test, assembly, and staging are areas of commercial potential for on-board work.

NASA Task Force on Commercialization

Question: In its report, the NASA Advisory Council Task Force on Commercial Uses of Space said that as productive as NASA's Outreach Program is, it needs refinement. Have any changes been made in NASA's Outreach Program in order to make it more responsive to the needs of the private sector?

If so, what are these changes?

Answer: NASA has revised its outreach program extensively in the last year. A commercial user development plan has been constructed that specifies and coordinates all marketing activities. Part of this plan calls for a contracted marketing effort by the private sector for NASA. The proposal was released on April 18, 1986. This contract will provide a concentrated effort to reach the nonaerospace market. Lastly, NASA is developing a method to coordinate the outreach efforts of the Field Centers. This effort consists of a management information system to track and coordinate Center work.

Effect of Shuttle Accident on Insurance

Question: What is your assessment of the Challenger accident's effect on the capacity and rates of insurance for commercial space endeavors?

Answer: It is too early to make an assessment of the Challenger accident's effect on capacity or rates of insurance for commercial space endeavors. To our knowledge, no one has gone to the market subsequent to the accident to obtain third-party liability insurance to obtain insurance for loss or damage to their own payload. However, one of NASA's contractors has expressed concern about its ability to obtain product liability insurance due to the fact that it is a prime contractor on the STS.

Question: Last year, this Subcommittee held a hearing on changes that had occurred with satellite launch insurance rates and capacity. The consensus was that the Federal Government should not intervene into that situation.

As a result of the Challenger accident, are circumstances different enough now to warrant Government intervention, and if so, how?

Answer: It is too early to make an assessment of the impact of the Challenger accident on the insurance market. Therefore, considering Government intervention at this time would be premature.

Senator GORTON. Our next witness is Dr. Edelson, but as he comes up we have a former member of the committee here, Senator Lautenberg.

Frank, if you would like perhaps partly to make an introduction and partly to make a statement, we will be delighted to hear it.

Senator LAUTENBERG. I really wanted to make a statement, Mr. Chairman, if I might.

Senator GORTON. Go right ahead.

STATEMENT OF HON. FRANK R. LAUTENBERG, U.S. SENATOR FROM NEW JERSEY

Senator LAUTENBERG. I appreciate the opportunity to be with you, with my former colleagues of the Commerce Committee, and I appreciate your accommodating my interest.

Some of you probably remember my strong interest in the NASA programs, especially the Advanced Communications Technology Satellite Program, and now I sit on NASA's Appropriations Subcommittee, but it is good to be back here where the authorizing decisions were made.

ACTS was one of my first Commerce Committee initiatives. When I joined this committee in 1983 we were confronted with the possibility that the ACTS Program would be scaled back to a ground-based program and the flight-based portion of the program would be eliminated.

Many of us in this room joined together and successfully protected the integrity of the ACTS Program by retaining the flight program.

Now in 1986 ACTS is once again threatened, this time with termination. In its fiscal year 1987 budget submittal to the Congress, the administration has recommended rescinding $27 million of fiscal year 1986 appropriations and terminating the ACTS Program.

The budget document states that this is part of the administration's effort to avoid possible competition with the private sector and to minimize Government subsidies for activities more appropriately and effectively undertaken by the private sector.

Now, I oppose this recommendation and urge the committee to confirm its support for ACTS. ACTS is an applied research program with considerable benefits to a growing segment of our economy. The communications satellite industry is a $2 billion enterprise that improves the U.S. trade balance, returns millions of dollars in tax revenue to the Treasury, and provides employment for tens of thousands of American workers.

Termination of this program will have far-reaching effects on American jobs and could lock the United States out of a growing international market.

There is no evidence that I have seen that the private sector will go it alone to develop this high-cost, high-risk technology. ACTS is an investment in America's economy and in our vital communications industry. The risks accompanying its development are best borne by existing public-private partnerships that have worked so well, and we should not gamble that the private sector will be able to pick up the ACTS development.

It is no secret that the Europeans and Japanese are investing substantial public funds in research in this area. To abandon our program now would cede a future market to our competitors and create the prospect of American communications firms purchasing foreign satellites launched on foreign launch vehicles.

I look forward to this opportunity to discuss the program with Dr. Edelson, and I thank you, Mr. Chairman, for your willingness to have me participate today.

Senator GORTON. Senator Lautenberg, thank you very much. You got us right into a vote.

Senator LAUTENBERG. I see that. Nothing like discontinuity.

Senator GORTON. I am going to keep as much continuity as we can get.

Dr. Edelson, I am going to have you start your statement now. Senator Hollings has left to vote, and I hope he will get back in time so that I can leave or Senator Rockefeller can leave, and we can certainly keep you going.

Do you want to go right now and try to get back?

Senator ROCKEFELLER. I will go with you.

Senator GORTON. You go ahead, Dr. Edelson, and if Senator Hollings is not back in time we will have a brief recess, but we will lose as little time as possible.

STATEMENT OF DR. BURTON I. EDELSON, ASSOCIATE ADMINISTRATOR FOR SPACE SCIENCE AND APPLICATIONS, NASA, ACCOMPANIED BY RON KONKEL, DIRECTOR OF ADMINISTRATION AND RESOURES; SAM KELLER, DEPUTY ASSOCIATE ADMINISTRATOR; AND JEFFREY D. ROSENDHAL, ASSISTANT ASSOCIATE ADMINISTRATOR, OFFICE OF SPACE SCIENCE AND APPLICATIONS

Dr. EDELSON. Thank you, Mr. Chairman, and members of the subcommittee. It is a pleasure to be here today to discuss the proposed fiscal year 1987 budget for the Office of Space Science and Applications.

I am accompanied here today by Mr. Sam Keller, the Deputy Associate Administrator, by Dr. Jeff Rosendahl, the Chief Scientist of the Office of Space Science and Applications, and by Mr. Ron Konkel, who is the Director of Administration and Resources of our office.

Senator GORTON. Excuse me. I do note, Dr. Edelson, that your statement is 28 pages long. It will be included in the record in full, and we would appreciate your summarizing it.

Dr. EDELSON. Thank you, Mr. Chairman. I have a much shorter statement.

Senator GORTON. The entire written statement will be in the record.

Dr. EDELSON. Thank you, sir.

The 1987 program as proposed will continue in the NASA tradition of excellence in space science and applications. It will maintain the momentum needed to ensure continued progress and at the same time strike the proper balance required by the conflicting requirements of fiscal constraint and scientific urgency.

This budget request was prepared prior to the tragic loss of the space shuttle *Challenger*. We are currently reviewing our planned missions with regard to schedules and priorities and will make adjustments. I will report on these adjustment activities later in my remarks.

The impact of the loss of *Challenger* on the Science and Applications Program will be very significant over the next few years. However, we will attempt to maintain a vigorous level of activity during the hiatus and during the slow return of our launch program.

Our Science and Applications Program does have sufficient breadth and momentum to permit a moderation of the impact on research, resources and opportunities by using to the fullest extent our operating spacecraft and the various other elements of our research base programs.

About 20 orbiting and solar system exploration spacecraft continue at the present time to provide high quality data that can support important research in many disciplines in astronomy, solar and space physics, planetary science and earth science. We will continue to insure the broadest use of these ongoing missions.

We will also work to maximize the use of our research and analysis funds—laboratory and ground-based experimentation, suborbital flights, theory and modeling and advanced instrument development—to keep the space and earth sciences as vigorous as possible pending the full restoration of shuttle flights.

The momentum and balance between research and flight projects so carefully cultivated in the past can help carry the program over the difficult postaccident period.

Before I turn to the specifics of our fiscal year 1987 budget, I would like to briefly mention one very bright spot, a very recent and important science highlight.

One of the most productive scientific missions ever undertaken by NASA achieved its third planetary encounter on January 24 when the Voyager 2 spacecraft flew within 50,000 miles of the planet Uranus. This feat was accomplished by a spacecraft launched eight and a half years ago and through a team effort of dedicated engineers and scientists from the Jet Propulsion Laboratory, from universities and from industry, all who overcame technical problems and performed engineering marvels at a distance of 1.8 billion miles from Earth and accomplished scientific observations and measurements of great value.

Voyager unveiled a world shrouded in mystery since its discovery 200 years ago and sent back valuable scientific data and spectacular photographs which I am sure you have seen of the planet, its atmosphere, magnetosphere, its moons, and its complex system of rings.

Voyager 2 is still healthy and on course for a 1989 rendezvous with the planet Neptune, the final port of call on its grand tour of the solar system.

Now to the budget. The total fiscal year 1987 research and development request for the Office of Space Science and Applications is $1,464,000,000. This funding level will support a balanced, well-structured program in many disciplines of science and applications.

It provides funds to initiate one new start, the ocean topography experiment, TOPEX. TOPEX will use an advanced radar altimeter and precise tracking system to measure the surface topography of the oceans from which ocean circulation can be determined.

Building on the close collaboration that has developed between the United States and the French oceanographic communities, TOPEX, as an international program, will be conducted jointly between NASA and CNES, the French national space agency.

Scheduled for launch on the Ariane launch vehicle in May 1991, a 3-year mission is planned. As the core element of an international scientific program, TOPEX will provide a critical capability needed to determine the circulation of the global oceans and to study their influence on global climate.

I might point out, Mr. Chairman, that TOPEX, No. 1 on our priority this year, was one program supported very strongly and put at the top of the list of both the science community and the applications community.

We are also in fiscal year 1987 requesting funds to provide solar-terrestrial instrument development for flights on European and Japanese spacecraft for participation in the International Solar-Terrestrial Physics Program.

We will also continue to develop the technology for Gravity Probe-B, a spacecraft which if ultimately approved for flight will perform an entirely new test of Einstein's General Theory of Relativity.

As part of the administration's effort to avoid possible competition with the private sector and to minimize goverment subsidies for activities more appropriately and effectively undertaken by the private sector, we are not requesting fiscal year 1987 funds for the Advanced Communications Technology Satellite [ACTS], the project mentioned by Senator Lautenberg.

Further, a rescission package for fiscal year 1986 appropriations of $26.8 million has been transmitted to the Congress.

Also, no fiscal year 1987 funds are requested for the Solar Optical Telescope Program. NASA does plan to continue solar research and advanced technology efforts. We are now reevaluating the mission scope and complexity of the Solar Optical Telescope [SOT] to determine if a reduced cost program can be developed to meet the most important objectives of that program.

Our 1987 fiscal budget will support preparations for several important programs which have been delayed by the *Challenger* loss and which have already been mentioned here this afternoon: the Galileo mission to Jupiter; the Ulysses mission to provide our first view of the sun and solar system from out of the ecliptic plane; and the centerpiece of our program, the Hubble Space Telescope.

In addition, the budget will provide funds to continue development on several other very exciting programs scheduled for later launches: the Gamma Ray Observatory; the Magellan; Venus Radar Mapper Mission; the Upper Atmosphere Research Satellite; and the Mars Observer. We are reassessing the launch opportunities for all of these missions at the present time, and this is a very difficult problem indeed.

In addition to the major programs, the fiscal year 1987 budget also supports the continuation of the Explorer Program. It supports the development of instrumentation and related mission management activities for spacelab and other space shuttle missions

Senator GORTON. Dr. Edelson, I am afraid Senator Rockefeller and I are going to have to go over there now or miss the vote. I would appreciate it, however, because there will be lots of questions, if you would complete your statement now and then whichever Senator returns first, he can have the first round of questions, so we will have time for questions.

Dr. EDELSON. Thank you, sir.

Our budget also supports continued planning for carrying out the science and applications missions on the space station and the associated platforms.

Our budget supports our broad-based research and analysis activities which is the core of our work in university laboratories.

Let me now turn to a discussion of the impact of both the Gramm-Rudman-Hollings legislation on our program and the replanning activities still in progress as a result of the *Challenger* accident. The committee has recently received NASA's proposed operating plan, which addresses both the program reductions mandated for fiscal year 1986 by the March 1 Sequestration Order and the initial program changes made necessary as a result of the *Challenger* accident.

As you know, there still remains a substantial uncertainty about the overall NASA budget for both fiscal years 1986 and 1987.

The Gramm-Rudman-Hollings reductions for the Office of Space Science and Applications total $75.6 million in fiscal year 1986. These reductions in our program followed an earlier reduction of $67 million in fiscal year 1986 as a result of congressional actions on the NASA fiscal year 1987 appropriations request.

Overall the, OSSA budget, post-Gramm-Rudman-Hollings, is $1,476.5 million or $137 million less than the request of the President a year ago. These combined reductions represent an 8.5 percent cut against our previously planned level for fiscal year 1986. Since the fiscal year 1986 budget provided for no new starts, all of these reductions have come out of our ongoing program activities.

We have worked hard to deal with these reductions in such a manner as to minimize the impacts on fundamental capabilities such as maintenance of scientific investigators at the universities and other elements of our scientific program. The resulting cuts against major ongoing flight programs have, however, placed us in the position of having far less flexibility in our budget for dealing with unforeseen technical problems or for dealing with the schedule and other programmatic changes made necessary by the shuttle accident.

We are currently engaged in a major replanning activity with our centers, assessing the dollar impacts of program delays and investigating schedule changes and other program modifications required to put our program back on a recovery path that will achieve our mission objectives.

We are making a major effort to understand the program alternatives available to us as we map a strategy for the recovery of the science and applications flight program.

For budget planning purposes we are assuming a 12-month stand-down of the shuttle leading to a flight of the Hubble Telescope and launch of Ulysses and Galileo as soon as possible, hopefully in the first 12 months of operation.

Our initial assessment of the costs associated with such a recovery program indicates that although some short-term reductions can be made in missions that will be delayed for several years or more, there are also substantial increased costs such as program stretchouts and from the requirements of having to maintain complex spacecraft on the ground in a manner that will insure successful launch and operations.

For the next few months we will be working with the NASA centers to develop a viable schedule to carry out the flight program of space science and applications missions essential to the continuing U.S. record of achievements.

That concludes my statement. Thank you very much.

Senator HOLLINGS [presiding]. We will await Senator Gorton's return.

With respect to what pressures may or may not have been brought to launch the *Challenger*, we had the Ulysses mission with the European space agency to investigate the Sun, and that was scheduled for launch on May 15 with a very narrow launch window, as well as the Galileo mission during the same window, as I understand it, between May 15 and June 9.

Science Magazine in their March 28 edition, stated that NASA internal agency documents indicated NASA had only one more day to launch that *Challenger* before it would be necessary to terminate the Ulysses mission for 13-months.

What is your comment? Is there anything to that? Are you familiar with that? That has been in the public press. We have heard, of course, from the astronauts themselve with respect to the pressure but it is the commercial part to which I am trying to restrict myself.

In your particular discipline and that particular program, is there any truth to that, any support for it? Do you have any knowledge of that at all?

Dr. EDELSON. Yes, I do have knowledge of it, Senator. The Ulysses mission, formerly known as the International Solar Polar Mission, was scheduled to be launched during a 20-day window in May. There was, however, a launch scheduled in between that and *Challenger* which was the Astro 1 mission, which I think was March 6.

So it was not the next succeeding mission.

Senator HOLLINGS. It was not the next succeeding one at all.

Dr. EDELSON. That is correct. It was the next launch of the *Challenger*.

Senator HOLLINGS That is what I am talking about. In other words, they had to get that back, get it in shape and everything else for that narrow window. I think it was only about 9 days, really, and that is a rather accelerated launch schedule I believe, as I understand, for the shuttle.

Yet they had to get it in at that particular time because you had the Centaur, which I want to get into, the upper stage that propels the payload, and there is some talk about delays there and whether or not that was ready.

Aside from that for the minute, did the schedule of the launching of *Challenger* on the Ulysses mission bring any pressure to absolutely require it to get off in that particular time?

I am only quoting Science Magazine. I am not chasing rainbows, but they reported that documents indicated that, and I am asking you if there are any indications of that at all?

Dr. EDELSON. It was a difficult and demanding schedule that the shuttle had to face. However, there were 4 months between the two launches of the *Challenger*, and we thought that that was adequate time to turn the *Challenger* around. And I do not believe that 1 day more or less would have made any difference.

Senator HOLLINGS. You know of no pressure brought on by that, then, at all?

Dr. EDELSON. I do not know of any at all, no, sir.

Senator HOLLINGS. Good. With respect to the Centaur upper stage, had all the critical tests been done? It seems like there had been, as I remember it—I do not see it noted here—some unusual delays in the upper stage that would propel that payload, but the program itself had been plagued by delays and cost overruns, is that correct, or what can you tell the committee about that?

Dr. EDELSON. Yes, that's correct, Senator. It was a very difficult, very challenging problem. The Centaur is a high energy hydrogen-oxygen fueled upper stage which had to be adapted from previously being launched on an expendable booster to be fitted in the space shuttle and be launched aboard the shuttle. That was a difficult task, and with safety foremost, there were many modifications that had to be made and many tests that had to be made.

There were cost overruns in the program and it was a difficult schedule, but we felt that the problems were mostly behind us and that we were going to make the launch.

Senator HOLLINGS. The Centaur upper stage was ready to fly?

Dr. EDELSON. It was in the process of final testing, and it was passing the testing very well.

Senator HOLLINGS. What remained to be tested, in a general sense?

Dr. EDELSON. Mostly avionics had to be tested. It did pass the critical test of cryogen fueling of the tanks.

Senator HOLLINGS. The requirements, then, dollar-wise, was it about $130 million, $180 million, in the cost overruns?

Dr. EDELSON. I don't have the budget figures, Senator. It's not my program, sir.

Senator HOLLINGS. I see. To keep the Galileo and Ulysses missions on schedule, were the Kennedy Space Center and contractor personnel working overtime?

Dr. EDELSON. They were indeed working overtime on the testing, particularly of the Centaur.

Senator HOLLINGS. I see. Well, let me yield now to Senator Lautenberg here for a minute.

Senator LAUTENBERG. Thank you, Mr. Chairman. I have just a few questions that I would like to get answers to, Dr. Edelson, and get them on the record, and make sure that we understand what we are facing as we strike down the ACTS programs, and the consequences that will result.

Dr. Edelson, at a hearing of the House Science and Technology Committee last month, NASA Administrator Graham told the committee that Federal assistance for ACTS was targeted for elimination because it could be developed by the private sector.

I understand that Dr. Graham suggested at the hearing that he had indications that the program would be continued by the private sector. I would be very interested in hearing from you what hard evidence NASA has to this effect.

Do you have any examples that give you some comfort, to show that the private sector is going to pick up this responsibility?

Dr. EDELSON. No, I have no such evidence, Senator. I believe that the technology that we were planning to develop or do have under development for the ACTS satellite is unique.

Senator LAUTENBERG. So, if it is unique and you share that view, and I do too, and we do not have any specific evidence that private companies are going to pick up the slack if the Government drops out of this public-private partnership, we could be missing not only an opportunity but a requirement if we are going to maintain a communications technology lead.

Last year, when the former Administrator, Mr. Beggs, testified before the NASA Appropriations Subcommittee, I asked him about our competitive status and he said, and I quote him here, he said, "The United States cannot remain competitive with other nations in all areas, but communications satellite technology is clearly one area where we are ahead and where our national security and economic interests demand that we stay ahead." That is the end of his quote.

How can we reconcile that statement with the administration's attempt to terminate ACTS? Are you challenging what Mr. Beggs said?

Dr. EDELSON. No, Senator, I would not challenge that.

Senator LAUTENBERG. Well, either he was wrong or we are wrong, and we both cannot be right. I mean, we have a program that is considered important by technicians, by the business community. It has meant an awful lot in development of our skills in the information era in which we live, and here we have two conflicting views.

One says, OK, the program that we are going to drop is going to be picked up by the private sector. We do not see any evidence of that. And we have this other statement by Mr. Beggs.

Dr. EDELSON. I think the administration's position, which you correctly quoted, Senator, is that the Government should not compete with the private sector in such a program.

Senator LAUTENBERG. If, in fact, the private sector will pick it up. I mean, obviously we have chosen the space program because we think it is essential. It obviously has, in addition to general science, the military skills, information. It is a program that there is so much support for, or have been programs that there has been so much support for before. No one has ever suggested that it be turned over to the private sector because we know it is just not going to be picked up for whatever reason.

And, here we have a business that lots of us—or an opportunity in technology that lots of us agree is essential if we are to remain in the technology edge, and we are saying that while we would like business and the private sector to pick it up, we have no assurances that they will do so.

I am just curious, how do you feel about the ACTS technology?

Dr. EDELSON. I do not think there is any question about the technology itself. My own feeling, based upon considerable experience in the satellite communications business, is that it is the technology that is required for communications satellites of all types in the next decade or two.

We designed and are developing the program to produce the technology that will be available and will be required in the years ahead, and will put the United States far in advance of anything that is known to be available elsewhere, specifically in Europe and Japan.

Senator LAUTENBERG. I appreciate your observation.

Senator HOLLINGS. Would the Senator yield there? ACTS is the only applied research program we have in NASA, and I understand you want to terminate it. Or, are you saying you are not terminating the ACTS Program?

Dr. EDELSON. We are not requesting any funds in fiscal 1987.

Senator HOLLINGS. Well, that is the best way I know to terminate something in the Government, don't you?

Heavens above. Now, we have not just the private sector, Dr. Edelson. I am over now on the defense side of the budget where they have put $75 million in there for your ACTS Program. DOD wants to get the laser communications systems tested and they are depending on you to do it, and so they have put $75 million in their fiscal year 1987 budget request. I have got DOD moving forward with ACTS on the one hand and NASA itself closing down the only applied research we have on the other hand.

And yet, you are telling me it is a wonderful thing that we are going to be ahead of everybody else by not asking for any money? Get me straight on that. I am confused.

Dr. EDELSON. There are two points at issue here. One is the technology valuable and useful, and I believe everyone agrees that it is. The question at issue is, is the Government by sponsoring and paying for this research doing something that private industry should do, and the administration position is that this is the type of development work which does have significant commercial value and therefore should be supported by the private sector.

Senator HOLLINGS. But then, in January 1985 we had that report of "Global Competition—The New Reality," and in that report, and I quote from it, "It should be U.S. policy to strengthen our science and technology base and its application toward enhancing the technological capabilities."

Senator LAUTENBERG. Mr. Chairman, something else that furthers the argument here, and that is that—and I respect Dr. Edelson's dilemma—professionally he acknowledges that this is a good technology, that it is an essential technology.

The dispute here is the idealogy, not the technology, and he suggests as the administration spokesman in this case that we ought to leave it to the private sector. The only thing is that none of us can find an example where the private sector is going to pick it up, so we have this dilemma and I appreciate some discomfort you may be going through because your professional integrity is well displayed here.

You believe the program is a good one. We know damned good and well, it's a good program. And you also, I think, Dr. Edelson would agree that the Japanese and the Europeans are targeting this area for development.

Are you familiar with their interest in these programs?

Dr. EDELSON. Very much so.

Senator LAUTENBERG. Can you tell us what their level of interest is? How much are these governments spending in this area, do you have an idea?

Dr. EDELSON. I do not have any specific knowledge. It is being targeted because it is known to be a very valuable area. Figures I do have is that there has been a total of about $10 billion of investment, commercial investment in communications satellite systems on a worldwide basis, $10 billion, that the annual revenues are approximately $4 billion per year, and that up until the present time about 80 percent of that has accrued to the United States.

Of that investment, in terms of spacecraft, launch vehicles, ground stations and so on, the INTELSAT system which is the worldwide system, has gone through five generations of satellites. Every one of those—six generations—every one of those has gone to a U.S. prime contractor.

Up until Ariane came along every one of those satellites, and there have been about 40 of them, have been launched by an American launch vehicle.

Senator LAUTENBERG. But there is a shift now taking place, and the Ariane is picking up a lot of slack and a lot of opportunity that we otherwise might have. It is my understanding that the Japanese are spending about $180 million a year, and about $140 million a year for the Europeans.

Mr. Konkel, do you have any knowledge of that?

Mr. KONKEL. No, I do not. I am sorry.

Senator LAUTENBERG. For ACTS, the Advanced Communications Technology Satellite, given the amount of interest and subsidy those governments, the Japanese and Europeans are providing, it is hard to find a way for the American private sector to compete in the development and marketing of such an expensive and high-risk technology. That is the concern I have.

Would you agree?

Dr. EDELSON. Yes, I do agree, and I think the issue is—let me repeat—as to who should provide the funding for the program. I think there is agreement on all sides that it is very valuable technology. In fact, the figures we are citing indicate that it is valuable, and is of immense commercial value, so the question of ideology is, if something is that valuable commercially, shouldn't the private sector step up to it and provide those funds.

And, that question is complicated by the fact that there is, as you pointed out, government-supported research and development going on in Europe and Japan in these areas.

Senator LAUTENBERG. See, there is also, I think, in addition to the commercial opportunities, some value to be obtained by our government in conducting this research. There is value obtained by being able to use the technology for communications within the

Government agencies, and across the globe. And private companies have invested millions in related development, and they have participated in the open bidding process and they were prepared to commit over $100 million in private funds.

And, the former Administrator Beggs called this a novel procurement approach, including cost-risk sharing arrangements with industry. It sounds like the ideal. I mean, my vision of Government is to do some seeding of projects and get it underway and then throw it out to the private sector.

And, it seems to me that NASA is dropping the ball and I wonder whether you think it is going to have an impact. I mean, what assurance do we have or what comfort level can we give the business and commercial community and those who would like jobs in this area, those who would like investment in this area? What assurances do we have that it is going to be made?

Dr. EDELSON. I cannot give you any assurances.

Senator LAUTENBERG. Thank you very much.

Thanks, Mr. Chairman.

Senator GORTON [presiding]. You are welcome, Senator.

Dr. Edelson, how will shuttle science be served with a three-Orbiter fleet? Particularly, how will university space science research programs be affected by the suspension of shuttle flights and by a future constrained launch capability?

Dr. EDELSON. Mr. Chairman, that is obviously a very difficult question and one which we are wrestling with all the time, and we have not come up with a final and agreed position on it. We are deeply involved in the replanning and we are assuming for the basis of the replanning operation that we will be launching the shuttle again in 12 months.

That means a resumption of shuttle flights in February 1987, that we will have nine launches in the first 12 months.

Senator GORTON. Those are extremely ambitious assumptions, aren't they?

Dr. EDELSON. Yes, sir, extremely ambitious. We will then have a gradual increase in the rate over the following 3 years, and then the assumption that we are making is that in 4 years another Orbiter will come on line. Those are the assumptions that we are making for program planning purposes, and for budget.

We have then analyzed our science requirements, all of the missions that we have in progress and planned, with special consideration of those missions that have launch windows and those that require shuttle flights of unusual orbits and so on, and come up with our own plan for shuttle flights that would satisfy all of the requirements that we have.

That would require, for science and application missions, three in the first 12 months and five in the next 12 months and so on, about one-third of all shuttle flights. We are working that schedule now and discussing it with other offices within NASA, and trying to negotiate the best arrangement that we can.

If we could attain that level, about one-third of the shuttle launch on that schedule, then we would have a healthy and vigorous program and meet all of our requirements, still with some delays and inefficiencies, but that would still be a good program.

Senator GORTON. This is the high line, is it not? This is the most favorable set of circumstances?

Dr. EDELSON. That is the most favorable set of circumstances, and that is likely to be degraded by virtue of the fact that the shuttle schedule is ambitious both as to resumption of time and launch rate. And second, we are liable not to get the priorities that we want relative to other customers for the shuttle.

Senator GORTON. That leads to another question. How do you intend to prioritize the launch of those space science and applications payloads?

Dr. EDELSON. Well, that is troublesome for us, Mr. Chairman, but within our own group we work it out, and we have done that in the past and we are continuing to do it now, and we have, as I have said, got a set of requirements that we have tabulated, worked out our own priorities, and I have sent it over to Admiral Truly and he is wrestling now with how he can accommodate that within the assumed schedule.

But as I mentioned, that is an ambitious assumption and that will be a difficult situation. I should have added to completely answer your question, that takes care of not only the flight missions but all of the instrument development, the science, the data analysis including the university work that goes along with the flight program.

Senator GORTON. On another subject, questions have been raised about the safety of the Centaur upper stage and its liquid propellant, particularly in the context of its use on the Galileo and Ulysses missions.

Do you have any safety concerns about the use of the Centaur in combination with radioisotope thermoelectric generators aboard a manned vehicle?

Dr. EDELSON. I thought we had a very good plan, Mr. Chairman, and I personally was satisfied with it. We worked very closely with the Centaur development group at headquarters, and at the Lewis Research Center and the General Dynamics Corp.

They had, as I pointed out, a very difficult task but they had done some excellent engineering and they had considered the safety aspects of the payload and of the shuttle and of the Centaur itself, and I personally felt that we were ready to go.

As far as the radioisotope thermoelectric generators were concerned, that again was a problem which we had analyzed very throughly. Let me point out that these power supplies are required, since on missions that are so far away from the sun, solar cell power supplies will not suffice so the radioisotope supplies are required.

We felt they had been engineered, studied and tested, and we were prepared to make the case with the interagency group that it was safe to go. We are now using this opportunity to re-evaluate all of that safety of the Centaur.

Senator GORTON. Your answer was in the past tense. You are going over it again, is that what you are saying?

Dr. EDELSON. That is correct. Now, with the time that we have to prepare and with the increased awareness of safety considerations and the obvious concern that we look into every aspect of design and engineering for safety, we are scrutinizing all of the safety considerations of the RTG's and of the Centaur upper stage, and I feel we will be ready to go when we get another launch opportunity.

Senator GORTON. Are there any circumstances under which you might feel that you had to use a different upper stage?

Dr. EDELSON. Well, the answer to that question is yes, that would be very expensive and difficult to do.

Senator GORTON. Expand on that. Could you also comment on whether or not you might launch one or both of these missions on ELV's——

Dr. EDELSON. We are looking at various opportunities, Mr. Chairman. It is complicated by a number of factors. First of all, there are only so many direct launch windows. We had planned to launch both Ulysses and Galileo during the same month, and it requires two Orbiters to be outfitted to do that.

We have looked at that situation, and feel that we would not wish to try to launch two such missions during the same month. So now, we are faced with only one direct launch window per year, that is, once every 13 months can we get a shot at the planet Jupiter toward which both missions go.

For various reasons we have looked at an alternative trajectory which would be applicable to Galileo but not to Ulysses, and that is an Earth gravity assist mode which launches at a different time of the year and requires less lift capability of the shuttle, which are advantages, but takes a longer mission time to get there, 4 years rather than 2 years to arrive.

So that, we are now looking at launching Ulysses in either June 1987 or July-August 1988, by a direct trajectory, and Galileo on what is called a Delta Vega—delta velocity Earth gravity assist mode, in either December 1987 or January, February 1989.

We have looked at the possibility of launching these by an expendable launch vehicle. The only possible one would be the large Titan 34-D-7 with a Centaur upper stage and a special kick motor. It looks feasible for Ulysses but not for Galileo at the present time.

A little aside. I think I got my wires crossed on a couple of points. We are now talking about the possibility of launching on a Titan vehicle, and what I said was—at least what I hope I said is Ulysses is a lighter launch and so we would have to launch that direct. But there would be no such vehicles available until about 1990.

These are various difficult and somewhat unpalatable combinations, but we are looking at them all. The concerns we have are that the shuttle lift capacity will be somewhat diminished because of added safety designs that will be put into the shuttle and into the Centaur and so that we will have to make some compromises in the missions either by launching in a different trajectory or cutting down the number of orbits which adversely affects the science mission. Those are very difficult studies, and we are involving the best people we can find at the Jet Propulsion Laboratory and other places to make these studies.

Senator GORTON. Have any safety waivers been issued for the Centaur?

Dr. EDELSON. Senator, let me make it clear that the Centaur vehicle, its design, test, and use is the responsibility of the Office of Space Flight, not Science and Applications. My knowledge of it comes as a user of it, and I am giving you my opinion as a customer willing to use it.

To my knowledge there were waivers of some engineering problems on the Centaur during the development program, but all of these at the present time are being reexamined, and have effectively been unwaived, and will be stringently considered and either changed by engineering design or after thorough review recertified.

Senator GORTON. I understand that the Department of Energy's final safety analysis report on the Galileo and Ulysses missions indicates that under certain circumstances a shuttle explosion at Kennedy Space Center could release enough radioactive material to contaminate 386 square miles and cause 43 cancer deaths over a 50-year period.

What is your assessment of this aspect of DOE's report? Is the risk described in the DOE report an acceptable level of risk?

Dr. EDELSON. I cannot certify to the numbers, but we have the report. I have read numbers like that. That is, Mr. Chairman, a theoretical analysis of all the possibilities that could happen, and to each of these possibilities are attached numbers, and frequently the numbers are something like 10 to the minus 6, one in a million or so, which is a very small number, somewhat similar to——

Senator GORTON. Do you know what the number is for the description that I have just given you, any of you?

Dr. EDELSON. I do not know, Mr. Chairman. We can find out all the details of that report, because they are contained in the report.

[The following information was subsequently received for the record:]

The Department of Energy's Update to the Final Safety Analysis Report for the Galileo and Ulysses Mission, dated December 17, 1985, contains data on a number of circumstances and situations that might occur if there were an explosion at the Kennedy Space Center involving either of these missions.

One of the possibilities estimates that such an explosion might contaminate about 386 square miles which could cause a number of deaths over an extended period. In the Report, probability of 1 in 100,000 has been assigned to this set of circumstances.

Senator GORTON. Go ahead. Had you completed your answer?

Dr. EDELSON. Yes, sir.

Senator GORTON. With the delay of the launch of the Space Telescope, how will it be stored to ensure its safety and security, and is any degradation likely to take place during the storage period?

Dr. EDELSON. It will be stored, Mr. Chairman, at the VATA, at the vertical assembly and test area at Lockheed Missile and Space Co., where it is being assembled and tested at the present time. We have kept it on schedule, on its original schedule for purposes of cost containment because it is the most cost effective thing to do to go through your testing procedures and so on, and also, it is best for morale, and you get the best quality job if you can keep the team on there to do that.

It will be finished about the end of June of this year, and then we will store it in that vehicle assembly and test area, and we will protect it to the best of our ability. As far as degradation is concerned, there are many areas in which it could degrade. It can collect dust, and that is of great concern, both particulate contamination and molecular contamination, so we will be very scrupulous to see that it is kept clean. Various rotating assemblies can degrade, such as bearings and so on, and we will energize those.

Various filaments will have to be activated over various periods of time, and so we will keep an active and knowlegeable engineering and test crew working to protect and exercise the vehicle and all of its subsystems for as many months as required until we can ship it to the Kennedy Space Center for launch, hopefully reasonably early in calendar year 1987, spring, summer, or at the very least the fall of 1987.

Let me say, not so incidentally, this is the centerpiece of our science program. I have maintained that it would be the best rallying point for the National Aeronautics and Space Agency, for the shuttle, for the science program, for our own morale, and for the prestige of the agency if we could work to get the Hubble Space Telescope in orbit and operating as soon as possible, and I am striving within the agency to get that as a key early launch in our program.

Senator GORTON. Good. I certainly agree with you in that connection. We have literally dozens of additional questions, as do other members of the committee. We do have a distinguished additional panel here whom we are going to have to hear completely by 5 o'clock, and so I am going to cut off the oral questions at this point and submit the balance of them to you, Doctor. Thank you for your help.

Dr. EDELSON. Thank you.

[The statement follows:]

Statement of

Dr. Burton I. Edelson
Associate Administrator
Space Science and Applications

National Aeronautics and Space Administration

Mr. Chairman, Members of the Subcommittee:

It is a pleasure for me to discuss the proposed FY 1987 budget for the Space Science and Applications Program. This program is an important part of our national space effort, and it has several distinct but related goals --- to discover new scientific information, to develop the technical capabilities necessary to make these discoveries possible, and to use these technical achievements to benefit this country and all humanity.

Our interests extend to the entire universe, with efforts ranging from the most distant galaxies to the neighbor worlds of the solar system, and finally to the land, oceans, and atmosphere of planet Earth. But we are more than just observers. We are also intensely concerned with using our abilities to the fullest extent to send humans and machines into space for long periods of time. We use the Space Shuttle to carry out experiments in Microgravity Science and Applications and Life Sciences. We develop new sensing methods to observe the Earth and advanced technologies for better communication and data management. And we plan new tasks that will use the Space Station in the 1990s and beyond --- large astronomical observatories, orbital laboratories, Earth Observing Platforms and major missions to other planets. The benefits we have realized from Space Science and Applications in the past have been enormous. Mankind now has a new view of the Universe.

The program we are proposing for FY 1987 will continue the tradition of excellence in Space Science and Applications. It will maintain the momentum needed to ensure continued progress and at the same time strike the proper balance required by the conflicting requirements of fiscal constraint and scientific urgency.

This budget request was prepared prior to the tragic loss of the Space Shuttle Challenger and its crew. We are reviewing our planned missions with regard to schedules and priorities, and will report any changes to you as circumstances warrant.

Before I turn to the specifics of the FY 1987 budget request, I would like to briefly discuss some of the highlights from the previous year. These missions and events are indicative of our excellent program in space science and applications.

HIGHLIGHTS

Voyager Encounter with Uranus

More than 200 years after the planet Uranus was discovered, the Voyager 2 spacecraft gave mankind its first close look at this curious planet and its once-unknown moons. In the twenty hours centered around Voyager 2's closest approach on January 24, 1986, we gathered more information about Uranus than we had in the 205 years since the discovery of the planet by William Herschel in 1781.

Discoveries of the Uranian system to date include: 10 new moons, a tenth ring around the planet, an unusual magnetosphere in which the planet's axis of rotation and the magnetic axis are offset to each other by about 55 degrees, an atmospheric helium content consistent with the distribution of elements in the solar system, unusual cloud rotations (movements) and winds of more than 100 m/sec (200 mph) in the atmosphere, the surprising discovery that the pole facing away from the sun is slightly warmer than the pole facing the sun, centimeter or larger sized particles (boulders) in the rings with a continuous distribution of very small smoke sized particles throughout the ring system, "fault valleys" that stretch across the surface of the moon Titania, possible past faulting and fluid flows on the surface of the moon Ariel, and strange grooved landscapes and incredibly high cliffs, which scientists can only describe as "stunning," on the moon Miranda.

In the execution of the Uranus Encounter the Jet Propulsion Laboratory's (JPL) Voyager Flight Team performed flawlessly, and the support provided by the Deep Space Network (DSN) and the JPL Flight Project Support Office was excellent. The well coordinated team effort has produced an extremely high yield of valuable scientific information which clearly justifies our continued commitment to the Voyager Program. Voyager 2 is now headed for an encounter with the planet Neptune in August, 1989.

SPACELAB 3

The Spacelab Shuttle missions flown so far have all carried important experiments for Earth Observations, and Spacelab 3 continued this tradition with its launch in April, 1985. One especially important instrument, the Atmospheric Trace Molecule Spectroscopy (ATMOS) experiment, provided excellent data on the amounts of important trace molecules (such as ozone) in the Earth's upper atmosphere and the first observations of certain key chemicals. The information acquired on basic physical and chemical processes in the upper stratosphere is important for understanding the mechanisms that control the amounts and distribution of ozone and other critical components in the upper atmosphere. In Microgravity Science and Applications, crystals were grown in orbit using both fluid and vapor techniques. And in Life Sciences, animals were tested and observed in orbit to provide data about the long-term effects of the microgravity environment on health. Results indicate that substantial decreases in muscle and bone mass occur in microgravity and that a number of other factors, including morphology, are markedly altered by weightlessness.

SPACELAB 2

The Spacelab 2 launched in July, 1985 culminated nearly ten years of preparatory work. It was an excellent example of international cooperation in space and successfully demonstrated two important devices developed by the European Space Agency (ESA): the igloo-pallet instrument platform and the Instrument Pointing System (IPS). The mission also obtained important data in various scientific fields: solar physics, plasma physics, X-ray and infrared astronomy, cosmic-ray physics, life sciences, and technology development. The orbital observations of the Sun obtained high-resolution images which showed solar features as small as 350 kilometers across. Such high-resolution images cannot be obtained over long periods of time from the ground because of turbulence in the Earth's atmosphere. Furthermore, a set of active plasma experiments were carried out using the Shuttle Orbiter Challenger, together with an electron beam generator and a small sub-satellite which was deployed and recovered during the mission. These experiments assessed the interaction of the Orbiter itself and the electron beam with the plasma environment. Scientists are now analyzing the data from this mission and comparing results to quantitative models; preliminary conclusions will be reported later this year.

International Cometary Explorer

The study of comets entered a new era last year when the International Cometary Explorer (ICE) made the first spacecraft encounter with a comet. ICE, formerly known as the International Sun-Earth Explorer (ISEE-3), was successfully diverted to comet Giacobini-Zinner and passed through its tail on September 11, 1985, making measurements of the comet's magnetic field, dust density, and composition. Results of this encounter were both exciting and surprising. The influence of the comet extended much further out into the interplanetary magnetic field than had been expected, and the most turbulent magnetic fields ever measured in space were detected near the comet's tail. Measurements indicate that water ice is the dominant material in the nucleus of the comet. A particularly surprising result was the relative absence of dust; far from destroying the spacecraft (as had been feared by some), only a few dust particles struck ICE as it passed through the comet tail. ICE is now on a course which will allow it to measure the solar wind about 30 million km. "upstream" of Comet Halley, and its observations will support intensive studies of the comet in April, 1986.

Satellite-Aided Search and Rescue System (SARSAT) Operational

The Satellite-Aided Search and Rescue System (SARSAT), developed by NASA and its international partners (Canada and France) and operated in cooperation with the U.S.S.R., which has a complimentary system, has met all of its specifications and was declared operational in July, 1985. The system has already been credited with saving more than 500 lives and has received worldwide acclaim. The potential for saving millions of dollars a year in search costs has been singled out as an example of benefits that can be obtained at reduced costs through international cooperation. Recently the International Civil Aviation Organization (ICAO) has recommended to its steering council that all member nations be invited to participate in the SARSAT program.

STS 61-C

During the January STS 61-C mission, Chairman Nelson conducted a series of biomedical investigations designed to further our knowledge on the physiological adaptation of the human body to the weightless environment. A set of closely integrated experiments dealing with cardiovascular, vestibular, and metabolic functions was successfully executed and new data on the human capacity to perform physical exercise was obtained. Such integrated experiments had not been performed in prior space missions and will form the basis for future biomedical experiments.

Infrared Astronomical Satellite (IRAS)

The past year also saw significant results in astronomy, and I am proud to report the scientific progress of investigations using data from IRAS. All of the data, both from the survey and from the pointed observations are now in the public domain and available to the world scientific community through the National Space Science Data Center. This enables scientists not connected with the development of IRAS to use the space data for research. We have also implemented a General Investigator Program using the IRAS space data. This first year of this continuing program resulted in 70 groups of U.S. scientists working with the data.

BUDGET REQUEST

The total FY 1987 Research and Development request for the Office of Space Science and Applications (OSSA) is $ 1,464.0 Million. This funding level will support a balanced, well-structured program in the different disciplines of Space Science and Applications. It provides funds to initiate the Ocean Topography Experiment (TOPEX) mission to provide global coverage of ocean surface currents and measure them with high precision and accuracy over long periods of time. We are also requesting funds to provide Solar-Terrestrial instrument development for flights on European and Japanese spacecraft, and Shuttle and free flyer instruments for U.S. participation in the International Solar-Terrestrial Physics (ISTP) program.

Consistent with Administration policy that the development of commercially oriented technology should be left to the private sector, we are not requesting FY 1987 funds for the Advanced Communications Technology Satellite (ACTS), and a rescission package for FY 1986 appropriations of $26.8 million has been transmitted to Congress. No FY 1987 funds are requested for the Solar Optical Telescope (SOT). NASA plans to continue solar research and advanced technology efforts in the science community to provide a basis for future flight opportunities to continue our support of scientific investigation in this area. We are re-evaluating the mission scope and complexity to determine if a reduced cost program can be developed to conduct these still important experiments.

This budget will maintain the U.S. leadership position in space science. It will support the Galileo mission to Jupiter, the Ulysses mission to provide our first view of the Sun and solar system from above the ecliptic plane, and the Hubble Space Telescope, the centerpiece of the space science program. In addition, the budget will provide funds to continue development on several other exciting programs scheduled for later launches: the Gamma Ray Observatory (GRO) (ready for launch in 1988); the Magellan mission (formerly the Venus Radar Mapper) (ready for launch in 1988); the Upper Atmosphere Research Satellite (UARS) (ready for launch in 1989); and the Mars Observer (ready for launch in 1990).

In addition to these major programs, the FY 1987 budget also supports the continuation of the Explorer Program. It supports the development of instrumentation and related mission management activities for Spacelab and Space Shuttle missions and for other missions of opportunity, and early development work on instruments and facilities to carry out Science and Applications missions on the Space Station and its associated platforms. The budget also supports our broad-based research and analysis activity, which is the core of our work in university laboratories.

I am confident that the budget level in this request will ensure a strong Space Science and Applications program. The details of this FY 1987 budget request are displayed on Charts 1 and 2. I will now briefly review some of the major elements of the program.

PHYSICS AND ASTRONOMY

In FY 1987, we request $539.4 Million for our Physics and Astronomy program, which includes the Astrophysics, Explorer, Suborbital, and Spacelab Program. In our Astrophysics program we continue toward our long-term goal of the comprehensive exploration of the universe by detecting and analyzing all the wavelengths of energy that reach us --- visible light, infrared radiation, X-rays, and gamma rays. We seek to answer some of the most basic questions about the Universe: How did it begin? Is it expanding? Will it have an end?

The Hubble Space Telescope (HST) will be ready for launch as planned this fall. This astronomical observatory may be the most significant tool for scientific discovery of our lifetime. Complementing HST, the Gamma Ray Observatory (GRO), scheduled for launch in 1988, continues under development. Further in the future, if approved we hope to complete our coverage of the entire electromagnetic spectrum with the Advanced X-Ray Astrophysics Facility (AXAF) and the Space Infrared Telescope Facility (SIRTF).

Hubble Space Telescope (HST)

For FY 1987, we request $27.9M for completion of the development effort, and $68.5M for operation of the Hubble Space Telescope (HST). Planned for launch in the fall of 1986, the HST represents a quantum leap in sensitivity, resolution and precision, operating near the theoretical limits of performance in astronomical observations of the Universe. HST is now in thermal-vacuum environmental test preparation. Detailed orbital simulations and functional tests have been successfully completed in ambient conditions. Results of all verification tests to date have confirmed that the HST performs at or better than the original specifications. Following the thermal-vacuum tests, pre-ship tests will be completed this spring, and HST will be ready for shipment to the Kennedy Space Center (KSC) by mid-summer of 1986. Ground system readiness will occur at about the same time. Long-range plans for the servicing of HST on orbit are in the final stages of detailed review. Although the plans for basic servicing capabilities and operations will remain essentially unchanged, planning details will be updated as required as final test data and actual orbital experience are obtained over the next several months.

Gamma-Ray Observatory (GRO).

The Gamma Ray Observatory (GRO) will be launched into Earth orbit in 1988 to provide a detailed view of the intensely energetic regions of the universe. It will detect, with unprecented sensitivity and resolution, the gamma rays emitted by especially violent objects such as quasars and black holes. For FY 1987, we request $51.1 million to continue development of this mission.

During FY 1986, assembly of all the instruments will be completed, testing and calibration of the instruments will begin, and fabrication of the spacecraft will continue. In FY 1987, testing and calibration of the spacecraft will be completed, and the instruments will be shipped to the spacecraft contractor, for integration and testing with the spacecraft.

Explorer Program.

We request $56.7 million in FY 1987 to continue development of the Cosmic Background Explorer (COBE), the Extreme Ultraviolet Explorer (EUVE), and several smaller projects. These missions will continue the Explorer Program tradition of producing unique and important new scientific results with relatively small missions.

Cosmic Background Explorer (COBE). COBE, planned for launch in 1988, will cover a spectral range from the near-infrared to microwaves in an effort to determine the nature and the large-scale structure of the radiation left over from the creation of the universe. During 1985 the instrument cooling unit (dewar) was delivered by Ball Aerospace Division to the Goddard Space Flight Center and passed all of its tests. Tests are now proceeding on the first of two cryogenically-cooled instruments, the Diffuse Infrared Background Experiment (DIRBE). The other instrument, the Far Infrared Spectrometer (FIRAS), will be ready for test in early 1986.

Extreme Ultraviolet Explorer (EUVE). EUVE will provide a view of the universe in the short-wave or extreme ultraviolet part of the spectrum which has received little attention so far. Design and fabrication of the EUVE instruments is now underway. In FY 1987, we will continue instrument development.

NASA is considering a new approach to providing the spacecraft platform for EUVE and for subsequent Explorer missions. We are studying the feasibility of retrieving the *Solar Maximum Mission (SMM)* spacecraft now in orbit, modifying it to form an Explorer Platform and then relaunching in 1989 with the EUVE experiment. After a year's operation, the EUVE experiment would be replaced on orbit by the *X-ray Timing Explorer (XTE)* now being defined. We view this plan as potentially the least expensive way to provide a refurbishable platform for future Explorer missions, and we will keep you informed of our plans when the feasibility analysis of this mission concept is completed.

Heavy Nuclei Collector (HNC). The HNC will be placed in Earth orbit to investigate the nature, source, and age of heavy cosmic ray particles that reach Earth from sources far outside the solar system. HNC is expected to collect enough of these rare atomic particles to provide key insights into the origin of cosmic rays and their propagation through space. In particular, searches will be made for elements heavier than uranium. The LDEF carrier is a relatively large (15' x 30') (20,000 lbs), but simple deployable spacecraft designed to accommodate a variety of passive experiments. The HNC experiments are comprised of layers of plastics and metals that will absorb cosmic ray particles, which will be analyzed upon return to earth. The simplicity of the LDEF carrier makes it an important low-cost experiment facility that can accommodate a variety of experiments that do not require pointing, power or communications. HNC is planned to be launched as part of the second flight of the *Long Duration Exposure Facility (LDEF-1B)*, following recovery in 1987 of the now on-orbit LDEF-1, launched in 1984.

Roentgen Satellite (ROSAT) Instrument. ROSAT, planned for launch in 1988, is a cooperative project between the United States, the Federal Republic of Germany (FRG), and the United Kingdom (UK). The FRG is building the spacecraft, an imaging X-ray telescope, and two of the three planned focal plane instruments. The U.S. is supplying the third focal plane instrument, a High Resolution Imager (HRI). The UK is providing a camera. The flight model of the HRI has been built and will complete qualification testing this winter. The HRI will then be shipped to Germany in April, 1986, for integration and testing with the ROSAT telescope. Principal U.S. efforts in FY 1987 will be directed toward the development of a ROSAT Science Data Center at the Goddard Space Flight Center (GSFC). This Center will be used for processing some of the ROSAT data and for distributing it to selected U.S. scientists.

Mission Operations and Data Analysis.

The FY 1987 request of $172.7M will support operations and maintenance and refurbishment for the HST and continue operations and data analysis support for the *Solar Maximum Mission (SMM)*, the *Infrared Astronomy Satellite (IRAS)*, and the *International Ultraviolet Explorer (IUE)*.

After being repaired by a Space Shuttle mission in 1984, the SMM spacecraft has continued to produce a series of exciting results about the Sun, including the detection of variations in the amount of energy radiated by the Sun. Between 1980 and 1984, the solar output measured by one instrument on SMM declined, and it was thought that this reflected a decline in the solar activity cycle. More recent data have shown a more complicated behavior and investigation of this data continues. The SMM spacecraft recently suffered a failure in the Tracking and Data Relay Satellite System (TDRSS) antenna. During a February 1986 maneuver to view comet Halley, the TDRSS antenna drive mechanism locked up and overheated. Failure analysis is underway to determine the necessary corrective action. This problem does not impact SMM data retrieval. The data is captured with the on-board tape recorder and relayed to Earth via the S-band antenna.

IRAS, launched in 1984 as a joint program with the Netherlands and the United Kingdom, discovered a quarter of a million sources this information is making a major impact in scientific investigations of many different objects, from planets to quasars. IRAS has given astronomers the first look at dusty comets in our solar system, at planetary systems forming around other stars, at stars in decay, and at enormously luminous galaxies.

IUE, a joint project with the United Kingdom and the European Space Agency, is one of the most prolific and successful Explorer missions. It is now entering its ninth year of continuous operation. High-quality ultraviolet observations of Comet Halley began in September, 1985, and have already produced important data for planning more intensive studies of the comet, such as the encounters of foreign spacecraft with the comet itself. More than 200 new proposals for observing time on IUE were recently submitted by scientists in more than half of the states and in several foreign countries. Successful proposals will be supported in FY 1987.

SPACELAB PAYLOADS.

During 1985, three Spacelab missions were successfully flown: Spacelab 3, Spacelab 2, (both highlighted earlier) and the reimbursable Spacelab D-1 mission of the Federal Republic of Germany (FRG). These flights all demonstrated the utility of the Shuttle/Spacelab system for carrying out important scientific studies in orbit.

For FY 1987, we request $115.1 million to continue flights of these important payloads. No funding is requested in FY 1987 for the Solar Optical Telescope (SOT). The $5 million in FY 1986 funds appropriated for this project will be used to provide for orderly phase down of contractor activities. NASA plans to continue solar research and technology efforts in the science community to provide a basis for future flight opportunities to support the scientific investigations in this area. In 1986 and 1987 we had planned to fly both the Astro payload and the Materials Science Laboratory (MSL). We also anticipated flying an Earth Observation Mission (EOM), a high-energy astrophysics mission, the first Life Sciences mission, a reflight of the SIR-B radar instrument, and the first International Microgravity mission. Because of the loss of the Challenger these missions will be postponed. However, they remain viable missions and will be flown as soon as launch opportunities become available.

The first operational Spacelab mission, Spacelab 3, flown in April, 1985, emphasized the microgravity and life sciences, but the mission also obtained important data for both astronomy and studies of the Earth's atmosphere. Spacelab 2, flown in July 1985, was the most complex mission to date, and clearly demonstrated not only the scientific and technical value of the Spacelab system, but also the enormous benefits and potential for cooperation with our international partners. The Spacelab D-1 flight in November, 1985 the majority of which was funded by the Federal Republic of Germany (FRG), also included some joint NASA/ESA Life Sciences experiments and the U.S. Materials Experiment Assembly (MEA) with three American experiments.

The Earth Observation Mission (EOM-1/2) originally planned for launch in August 1986, will be scheduled to fly at a future date and will refly several instruments that flew on Spacelab 1. It will also be the first of a recurring series of Shuttle flights to study long-term changes in solar irradiance and to monitor changes in chemical composition of the middle and uppermost parts of the Earth's atmosphere over an entire 11-year solar cycle. That series will correlate measurements with the Upper Atmosphere Research Satellite (UARS), scheduled for launch in 1989. Comparative measurements will be made by underflying UARS with the Shuttle payload to obtain simultaneous measurements of the same regions of the atmosphere. *EOM-1/2* will carry out 16 experiments contributed by four countries in addition to the United States --- Belgium, France, Japan, and the Federal Republic of Germany --- in six different scientific disciplines: atmospheric science, solar physics, Earth observations, plasma physics, astronomy, and life sciences.

PLANETARY EXPLORATION.

The FY 1987 budget request for Planetary Exploration is $323.3 million, and includes funds for continued development of two future missions: *Magellan* (formerly the *Venus Radar Mapper*) and the *Mars Observer*. It also includes funds for the continued operation of existing spacecraft and for supporting activities.

Galileo.

The *Galileo* mission to Jupiter, a joint project with the Federal Republic of Germany, is planned to make a comprehensive long-term study of this giant planet, its atmosphere, its huge magnetic field, and its unusual moons. The spacecraft has two parts: an Orbiter to make the long-term surveys and an atmospheric Probe that will enter the atmosphere and make direct analyses of its composition. Although the Galileo mission has been postponed because of the loss of the *Challenger*, we will proceed with planned tests to ensure that all interfaces between the spacecraft, their upper stages, the Shuttle and the launch facilities are validated prior to launch.

During 1985 the integration and testing of the spacecraft subsystems progressed well. Development of the flight software was completed, and the software was tested on the spacecraft. New radiation-hardened electronic microcircuits were fabricated, tested, and installed in critical subsystems to prevent computer failures caused by radiation events in outer space. Testing of the atmospheric Probe was completed, and the Probe was integrated and tested with the spacecraft in all mission modes. The *Galileo* spacecraft was shipped to the Kennedy Space Center (KSC) in late December. At KSC, the Radioisotope Thermoelectric Generators (RTGs) that supply the power will be installed, and the spacecraft will be mated to the redesigned Centaur stage that will launch it toward Jupiter from Earth orbit.

Ulysses.

Ulysses, a cooperative effort between NASA and the European Space Agency (ESA), will provide our first view of the Sun and the solar system from above the ecliptic plane, looking down on the Sun. By making comparative measurements over a wide range of solar latitudes, the mission will be able to study in detail the Sun's magnetic field and the streams of atomic particles ejected from the Sun in the solar wind and solar flare eruptions. The data obtained will provide fundamental knowledge about the Sun and will also give us a better understanding of the effects of solar activity on the Earth's weather and climate. During 1985, pre-launch testing of the spacecraft and its instruments was completed at ESA, and the spacecraft was shipped to KSC in early January. Testing of the joint NASA/ESA ground system is proceeding satisfactorily. Although the launch date for *Ulysses* has been postponed because of the loss of the *Challenger*, we will continue with planned tests to ensure that all interfaces between the spacecraft, RTG's, the upper stages, the Shuttle and the launch facilities are validated prior to launch.

Magellan (Venus Radar Mapper).

The *Magellan* mission, previously known as the *Venus Radar Mapper*, is designed to map the surface of Venus using a radar system on an orbiting spacecraft to penetrate the thick, permanent clouds that hide the surface. Over an eight month period, the entire planet will be mapped with a ground resolution of better than one kilometer, and specific regions will be mapped with resolutions as high as 125 meters. The program has made good progress preparing for launch in April, 1988 on a Shuttle/Centaur-G combination. The FY 1987 budget request of $66.7 million will continue development of Magellan.

In 1985, critical design reviews for Magellan were conducted for the radar and spacecraft systems. Fabrication of the radar unit and the spacecraft subsystems was initiated, and the spacecraft subsystem is scheduled for delivery in 1986. The radar system is scheduled for integration with the spacecraft in FY 1987, and the assembly and testing of the spacecraft will then begin. Development of the ground operations system will be completed and tested for compatibility with the spacecraft system at about the same time.

Mars Observer.

The Mars Observer mission, planned for launch in August 1990, is the first in a series of missions to explore the inner solar system. It will place an orbiting spacecraft around Mars in 1991 to make global studies of the geology and climatology of the Red Planet. Observations of the atmosphere, the surface, and the gravity and magnetic fields will be made for a full martian year (almost two Earth-years), making it possible to study the geological activity, atmospheric dynamics, and climatic factors on a global basis over a full martian seasonal cycle. The mission was approved as a new start in FY 1985, and development is proceeding. In FY 1987, $62.9 million is requested for continued development of the mission.

A Request for Proposals for the Mars Observer spacecraft and flight system and Announcement of Opportunity for scientific investigations were issued in 1985, and we expect to complete the selection process for both the flight system and the instrument payload in 1986. In FY 1987, experiment confirmation reviews will be held, flight system design reviews will be conducted, and ground system specification plans will be confirmed.

Mission Operations and Data Analysis.

The FY 1987 request of $130.2 million will support five major operating spacecraft: Voyager 1 and 2, Pioneer 10 and 11, and the Pioneer Venus Orbiter. Minor support is also provided for four other flying spacecraft: Pioneer 6, 7, 8, and 9. The Galileo and Ulysses missions will also be supported by this program once they are launched.

Voyager Program. Voyager 1 and 2 are now passing through the outermost solar system on trajectories that will eventually take them into interstellar space, never to return. Voyager 1, which is on a trajectory taking it out of the ecliptic plane, is already past the orbit of the planet Uranus, and continues to provide data on the nature of the interplanetary medium in this distant part of the solar system. Voyager 2 made the first spacecraft encounter of Uranus itself on January 24, 1986, providing our first close-up view of this mysterious planet, its rings, and its satellites. Analysis and interpretation of the data are underway.

Pioneer Program. Pioneer 10 and 11 continue their explorations through the outermost reaches of our solar system. Pioneer 10, which passed the orbit of Neptune last year, is now passing through the unexplored region near the more distant reaches of the orbit of Pluto. Pioneer 11, near the orbit of Uranus, supported the January Voyager 2 encounter with Uranus by providing background measurements of the magnetic field of charged particle intensities in the general region of Uranus.

The Pioneer Venus Orbiter (PVO) spacecraft was reoriented late last December to make unique long-term observations (spanning several weeks) of Comet Halley in ultraviolet wavelengths. These observations provided the only data about Comet Halley when it was closest to the Sun and most active; during this time, the comet was hidden to view from the Earth and from all the other spacecraft approaching it. Images of Halley's hydrogen coma were obtained, water sublimation rates were measured, the effects of comet brightening on the sublimation rate were also measured and the effects of solar pressure on the hydrogen coma were also captured. The PVO spacecraft resumed observing the planet Venus from its highly elliptical orbit on March 3, 1986 and it is continuing to obtain new data from yet-unexplored regions of the planet's atmosphere and ionosphere.

EARTH SCIENCE AND APPLICATIONS.

In FY 1987, $442.0 million is requested to support the Earth Science and Applications programs identified under the categories of Solid Earth Observations and Environmental Observations. Investigations of the land and solid interior of the Earth are the focus of Solid Earth Observations efforts, while Environmental Observations efforts are concerned with the Earth's oceans, atmosphere, and magnetosphere. The overall goal of all these programs is to understand the processes and interactions between the Earth and its near-space environment as well as related space plasma phenomena throughout the solar system. We study these processes with a combination of spacecraft missions, suborbital experiments, and supporting research and analysis, all with the aim of understanding these processes well enough to develop predictive models for such phenomena as ozone variability, ocean circulation, weather, and climate.

Ocean Topography Experiment (TOPEX).

In FY 1987, $29.0 million is requested to initiate development of the Ocean Topography Experiment (TOPEX) mission. TOPEX will use an advanced radar altimeter and tracking system to measure the surface topography of the oceans, from which ocean circulation can be determined. This measurement technique was successfully demonstrated in 1978 by the flight of NASA's Seasat spacecraft. Extensive studies, conducted over the past five years by NASA, industry and the French Space Agency (CNES), have demonstrated that the implementation plan for TOPEX is technically feasible, low risk, and cost effective. Building on the close collaboration that has developed between the U.S. and French oceanographic communities, TOPEX will be conducted as a joint mission with NASA and CNES. The CNES contribution to the TOPEX mission will be an experimental altimeter and a second tracking system for flight aboard NASA's TOPEX satellite, as well as a dedicated Ariane launch for the satellite itself. Scheduled for launch in May 1991, a three-year mission is planned.

Planned as the core element of an international scientific program, TOPEX will provide a critical capability needed to determine the circulation of the global oceans and to study their influence on global climate. TOPEX will overlap in time both the flight of the NASA Scatterometer (NSCAT) on the U.S. Navy Remote Ocean Sensing System (N-ROSS) satellite and the large field programs of the international World Ocean Circulation Experiment (WOCE) and the Tropical Oceans Global Atmosphere (TOGA) experiment. The NSCAT instrument will measure surface marine winds, the primary driving force of the ocean circulation. During WOCE, oceanographers will directly measure both surface and subsurface currents. The understanding gained from studying the combined TOPEX, NSCAT and WOCE and TOGA data sets will pave the way for future development of predictive models for the Earth's climate.

Upper Atmosphere Research Satellite (UARS).

In FY 1987, $152.2 million is requested for continued development of the Upper Atmosphere Research Satellite (UARS) mission, which was approved as a new start in FY 1985 and is scheduled for launch in the fall of 1989. This mission is a critical element in NASA's comprehensive program of research, technology development, and monitoring to understand the natural variability and the effects of human activities on the atmosphere. UARS will provide the first complete, integrated global measurements of ozone and other key chemical species, energy input, temperatures, and winds in the stratosphere and mesosphere.

In FY 1985, the design and construction of all of the ten UARS scientific instruments went forward. In March a contract was signed with General Electric's Space Systems Division for construction of the instrument support structure and for integration of the complete instrument module with a NASA-furnished Multi-Mission Support (MMS) module. During FY 1987, design, construction, and integration activities will continue, and science data interpretation techniques will be further developed by the selected Principal Investigator teams.

Scatterometer (NSCAT).

The FY 1987 budget request includes $35.9 million to continue development of the Scatterometer (NSCAT), a radar system to be flown on the U.S. Navy Remote Ocean Sensing Survey (N-ROSS) satellite in 1990. NSCAT is designed to make accurate measurements of the surface wind over the oceans. Beyond satisfying U.S. Navy operational requirements for improved marine forecasting, NSCAT will provide a capability to undertake the first global study of the variability of marine winds; and, in concert with TOPEX, it will enable an understanding of how atmospheric winds drive the circulation of the global oceans. Design and development activities for NSCAT were initiated in FY 1985. During FY 1986, a successful preliminary design review was conducted, the RFP for the high voltage power supply was issued, the selection process for scientific investigation was completed, and the first of three planned ground computer systems was delivered. In FY 1987, hardware components will be delivered, fabrication of the radio frequency subsystems will begin, the second computer system will be procured, and the critical design review will be completed.

Solid Earth Observations and Environmental Observations Payloads and Instrument Development

The FY 1987 budget request contains $33.6 million for the continued development of Earth Science and Applications Shuttle and Satellite Payloads. These will include the reflight of some instruments that were previously flown on the Shuttle, for example, Measurement of Air Pollution from Space (MAPS), Atmospheric Trace Molecule Spectroscopy (ATMOS), Feature Identification and Location Experiment (FILE), and Active Cavity Radiometer (ACR-1), with refurbishment and modifications to be made as necessary. We will continue definition, design, and construction of advanced instruments such as the Shuttle Imaging Radar-C (SIR-C), the Shuttle Imaging Spectrometer Experiment (SISEX), the Solar-Terrestrial Atmospheric Sounder (STAS), and the Shuttle Light Detection and Ranging (LIDAR) instrument for global measurements of clouds and atmospheric aerosols.

Some of these instrument development programs, especially SIR-C, suffered significant setbacks last year due to the loss of the CV-990 research aircraft in a runway accident on July 17, 1985. This "flying laboratory" was used as a test bed for new remote sensing techniques, and it also provided comparative measurements during flight for a number of Shuttle-based Earth observation experiments. We are in the process of replacing this critical capability with a series 72 DC-8 aircraft which will provide the required platform and be compliant with the latest noise suppression requirements. This was not the case with the former aircraft.

Special emphasis in the near future will be given to the development of Shuttle and free-flyer instruments for U.S. participation in an international effort in Solar-Terrestrial research in the 1989-1995 time period. Most of these instrument concepts have already been demonstrated through the Space Plasma and Solar Physics Research and Analysis programs, through the Sounding Rocket Program, and through earlier exploratory flight missions. These development efforts will be concentrated to take advantage of a variety of domestic and international flight opportunities, and they will be focused toward answering key questions about the nature of sun-earth interactions. Near term international flight opportunities include the Japanese Institute of Space and Astronautical Science (ISAS) Geotail mission and the European Space Agency (ESA) Cluster and SOHO missions.

Mission Operations and Data Analysis.

In FY 1987, $33.6 million is requested for Earth Science and Applications Mission Operations and Data Analysis to support operations and the processing, validation, and analysis of data from currently orbiting spacecraft. Nimbus, Solar Mesosphere Explorer (SME), and Earth Radiation Budget Experiment (ERBE) satellites continue to provide valuable information about the atmosphere and oceans. Data on the important near-Earth space environment are still being obtained by the International Sun-Earth Explorers (ISEE 1 and 2), the Dynamics Explorer (DE-1), and the Active Magnetospheric Particle Tracer Explorer (AMPTE). In the area of solid-Earth observations, we also plan to continue the acquisition and analysis of global measurements of tectonic plate motion and Earth rotation in the Geodynamics Program, supported by NASA laser network operations. In September, 1985, the Department of Commerce signed a contract with the EOSAT Company for operation of the Landsat satellites and marketing of unenhanced Landsat data. NASA's direct communications with EOSAT involve the purchase of Landsat data for NASA research and development activities, as well as discussions of a possible cooperative program to develop an Advanced Landsat System.

LIFE SCIENCES

In FY 1987, $74.7 million is requested for continued activities in the Life Sciences Program. This program supports a wide range of studies involving human beings living and working in space --- research on the effects of microgravity on living organisms, advanced technology development for flight crew systems, and medical operations for all manned missions. We have recently begun preparing for long-duration manned missions involving the future Space Station.

Life Sciences also supports research aimed at several related goals --- to increase our understanding of the origin, evolution, and distribution of life in the universe; to develop practical techniques for producing air, water, and food in space in order to minimize mission resupply problems; and to contribute to NASA's interdisciplinary research program directed to understanding the effects of biological influences on the Earth.

In FY 1985, Life Science experiments were conducted on six Shuttle missions and one U.S.S.R. mission. The results are still being analyzed but some important initial findings have already appeared. The Spacelab 3 mission contained the most comprehensive set of animal studies in the history of U.S. space flight, and provided important data on inner ear function, muscle atrophy, and bone loss in space. The U.S.S.R. Cosmos 1667 flight in July 1985 provided the first accurate measurements of blood pressure and blood flow in primates during space flight. The blood measurement experiment as well as a time code generator and spacecraft internal pressure transducer were developed and provided by the U.S. All pre-, post and inflight data collected from these instruments by the U.S.S.R. on their recorders was provided to the U.S. This data is now jointly being analyzed to understand how the heart and circulatory system adjust to space flight. Some of the Space Shuttle missions included experiments in the area of human research in space, and new results were obtained about the adaptation and function of the inner ear and balancing systems, and these investigations have indicated some new approaches for dealing with and/or preventing space motion sickness. Valuable information about the behavior of the human heart and circulatory system in space was obtained from echocardiograph investigations carried out on flight crew members, including Senator Jake Garn. Representative Bill Nelson participated in a study of how the body responds to exercise in weightlessness. A new technique was developed to measure bone strength easily, rapidly, and accurately in order to monitor calcium loss from the bones in space. This method is being evaluated for application on Earth, for possible clinical use in the early detection of bone weakening (osteoporosis) caused as a result of aging and/or menopause.

In FY 1987, the Life Sciences Program plans to continue use of the Shuttle/Spacelab system to gather valuable data on medical, biomedical, and biological processes in Earth orbit. We will also continue preparation of experiments for the first dedicated Space Life Science (SLS-1) orbital laboratory, using the Spacelab module.

In the area of Biomedical Research a special concern is the reduction of muscle and bone strength produced in the low-gravity environment of space. These changes may continue as long as the person is in space, and they pose a serious consideration in planning for long duration space missions. Another concern for long-term spaceflight is the potential for increased exposure to ionizing radiation from space. During such flights, humans are subjected to cosmic radiation that could produce permanent cell damage if the dose is too high. Research in radiation biology is now trying to define how much radiation can be expected and tolerated.

Also important is the continued provision of air, food, and water to the crews. The Controlled Ecological Life Support Systems (CELSS) research program is studying various practical approaches to produce food, air, and water for an entire crew by developing a continuously recycling system small enough to be included in the design of future spacecraft.

In Gravitational Biology research plants flown in space have exhibited chromosomal abnormalities, delayed cell division, and abnormal growth. These effects suggest that the weightless environment has produced significant changes in plant metabolism. Flight results of this kind have stimulated an increased recognition of the importance of understanding the effects of gravity (and its absence) on the development and function of living organisms.

Exobiology research continues to produce some exciting results about the origin and development of life on Earth. Recent studies of models for the primitive Earth, coupled with analyses of meteorites, observation of comets, and analyses of both interstellar molecules and planetary atmospheres, indicate that the basic molecular ingredients for life are abundant in the universe. In FY 1987, we plan to address these important questions by developing specific Exobiology flight experiments to (1) simulate the physical and chemical processes involved in forming interstellar dust grains, and (2) develop methods for the actual collection in space of cosmic dust particles in their pristine, unaltered state. Both types of experiments will provide otherwise unobtainable insights into how the precursor molecules essential for the development of life were created in the universe. We will also continue to define requirements for the conduct of a search for extraterrestrial intelligent life in preparation for a future initiative in this area.

MICROGRAVITY SCIENCE AND APPLICATIONS.

In FY 1987, we request $43.9 million for Microgravity Science and Applications. The goals of this program are: (1) to conduct basic research on the effects of the microgravity environment of space in order to understand the basic phenomena of physics, chemistry, and materials science; (2) to apply the results of this research to develop practical applications; and (3) to provide for the wide dissemination of experimental results to the U.S. industrial, governmental, and academic communities. We are working to implement the recommendations of the NASA Advisory Council Task Force on the Commercial Uses of Space, that the wide dissemination of this information is essential to providing the sound research base needed to make the commercial use of space a reality in the near future.

During FY 1987, our program will pursue active flight and ground research programs in six different disciplines: metals and alloys; electronic materials; glasses and ceramics; biotechnology; combustion science; and fluid dynamics and transport phenomena.

Our program of space flight research experiments makes maximum use of the unique capabilities of the Space Transportation System. The Materials Science Lab (MSL) experiment carrier, completed in 1985, will become the workhorse of the Microgravity Research Program in the future. The MSL is planned to fly four times per year, and new apparatus is now being developed for future flight on the carrier. One of these, the Advanced Automated Directional Solidification Furnace, planned for completion in 1988, will make it possible to carry out more sophisticated experiments on metals, alloys, and electronic materials. In addition to the MSL, we are continuing a program which uses the middeck area of the Shuttle for individual experiments. A total of eight experimental devices are now available for flights in the middeck area, and an additional four devices are now under development. One current middeck experiment, the Initial Blood Storage Experiment (IBSE), is a series of studies to explore the question of storage limitations on the various components of human blood. Ground-based research done to prepare for the flights of IBSE has already led to new procedures which extend the shelf life of blood stored on the ground. We are also participating in several Spacelab module and MSL experiments, in cooperation with both Japan and the Centre National d'Etudes Spatiales (CNES)European Space Agency (ESA). This cooperation makes possible the use of foreign equipment and foreign research material by U.S. researchers, a process that substantially increases our flight research base.

The Microgravity Science and Applications program also maintains an active program of ground-based research and experimental facilities that provide essential contributions to the development, operation, and interpretation of our flight experiments. The Microgravity Materials Science Laboratory (MMSL) is now in operation at the Lewis Research Center in Cleveland, Ohio. Its purpose is to provide easy access to Shuttle-type space flight equipment for researchers interested in conducting flight experiments in space. The MMSL provides an opportunity for researchers to briefly explore microgravity science concepts and to examine ideas aimed at potential flight experiments before a formal research effort is established. In this way, the MMSL expands the opportunities for interaction between industry, government, and academic researchers and will contribute significantly to the identification of commercially viable materials science concepts and experiments.

COMMUNICATIONS.

In FY 1987, we request $19.5 million to support continued activities of the Communications program. Activities include Technical Consultation, Experiment Coordination and Operations Support, and Research and Analysis. The Research and Analysis effort supports the development of mobile and laser communications satellite experiments and develops the new technology needed for future satellite expansion and operations. No funding is requested in FY 1987 for the Advanced Communications Technology Satellite (ACTS) Program. The development of this commercially- oriented technology should be left to the private sector.

Satellite-Aided Search and Rescue (SARSAT).

We request $1.0 million in FY 1987 to continue support of system engineering efforts and to develop new technologies for the Satellite-Aided Search and Rescue (SARSAT) Program. This international search-and-rescue system has already been credited with saving over 500 lives. Four satellites are now in service, two from the U.S. and two from the U.S.S.R. The current ground system consists of six mission control centers in the U.S., Canada, France, Norway, U.S.S.R. and Great Britain together with 10 local user terminals.

During FY 1987, we plan to complete development work on the SARSAT ground system, and we will also carry out an experiment to evaluate the benefits for search-and-rescue operations that could result from making possible instant alerts through the use of geostationary satellites. Other technologies that could increase the system's ability to detect and locate persons in distress will also be developed and tested during FY 1987.

Experiment Coordination and Operations Support.

This effort supports the continued operations of the Applications Technology Satellite (ATS) spacecraft and provides for the development and coordination of associated experiments. In FY 1987, $1.3 million is requested for these activities.

ATS-1, a 19-year-old experimental satellite which had provided humanitarian telecommunications services to 23 isolated Pacific islands for the last 14 years, was shut down last year when it would no longer respond to station-keeping commands. At the request of Congress, NASA is currently evaluating options to provide a replacement satellite for the ATS-1 users in the Pacific Basin. The only remaining ATS satellite, ATS-3, will continue to provide a two-way capability for voice and data transmission for a number of scientific experiments being conducted in such widely-separated areas as North America, Antarctica, and both the Atlantic and Pacific Oceans. ATS-3 continues to be an important link for emergency communications in the Western Hemisphere, demonstrating its value during the recent earthquake in Mexico City and the disastrous volcanic eruption in Columbia.

Technical Consultation and Support Studies.

In FY 1987, $3.2 million is requested for our Technical Consultation and Support Studies program. This program provides the technical basis for the development of regulations and policies that will assure the orderly growth of both existing and new satellite services.

During 1985, our studies and participation in the Space World Administrative Radio Conference (SWARC) contributed greatly to the successful outcome of that conference. Also in 1985, we carried out measurements of radio wave propagation using balloons, drone aircraft, and helicopters; these experiments have provided new insights to industry on the effects of trees and foliage on mobile satellite communications.

In FY 1987 we will also carry out studies to prepare for two important international conferences: the second session of SWARC, which will be held in 1988, and the World Administrative Radio Conference (WARC), which will be held in 1987. We will also continue to identify techniques that can increase the efficient use of two critically limited resources for satellite communications --- orbital space and the crowded radio spectrum.

INFORMATION SYSTEMS.

For FY 1987, we request $ 21.2 million to continue our multidisciplinary Information Systems program. This program supports all Space Science and Applications flight projects and science programs in two ways: (1) by managing major NASA computational resources and (2) by developing the advanced technologies needed to handle efficiently the massive amounts of data acquired from successful space missions.

Several major data processing systems used by researchers to make large-scale computations and to test complex scientific models are located at the Goddard Space Flight Center (GSFC). These include the large-scale IBM, CDC, and AMDHAL computers in our Space and Earth Science Computing Center (SESCC). In addition, the program is responsible for the National Space Science Data Center (NSSDC), which ensures the continuing availability of data from NASA's satellites and rocket flights.

In FY 1986, we restructured the NSSDC, increased its staff and computational resources, and began implementing nationwide electronic access to distributed data catalogs. In addition, through our "pilot" data systems program, we have developed new capabilities to more effectively manage and distribute the large amounts of data from space missions. These "pilot" systems are testbeds, designed for a specific science discipline, that are used to evaluate and demonstrate new and cost-effective computer technologies. As part of this program, the Pilot Ocean Data System was completed in FY 1986 and was transferred to the Ocean Processes element of the Earth Science program to support both their ongoing research efforts and the study of the planned N-ROSS and TOPEX missions. The Pilot Planetary System was integrated with the Planetary Research program as the nucleus of their future planetary data network.

In FY 1987, we will continue to develop improved systems capabilities for the management of space data. We will also provide technical consultation in key areas, such as Earth science, planetary science, astrophysics, and Space Station studies. We intend to emphasize improving access to NASA data, developing data standards, and planning for the Space Station era. We will also begin to integrate the widely separated Space Science and Applications data centers into a unified information network to support interdisciplinary research. Such a unified data management capability will be needed by all Space Science and Applications programs and flight projects in the 1990s, especially for such major efforts as the potential new Earth Observing System (EOS) mission, if approved.

SUPPORTING PROGRAMS

Supporting programs in Suborbital Research and in ground-based Research and Analysis are an essential complement for all Space Science and Applications flight mission activities. Suborbital flights of balloons, aircraft, and sounding rockets provide observations that complement the results of more complex orbital missions and also facilitate the development and testing of instruments that will eventually make orbital observations. The ground-based Research and Analysis program provides even more diverse and essential support functions: theoretical studies, laboratory research, instrument and mission definition and development, ground-based observations to support flight missions, and extended analysis of data from completed missions. The supporting programs are a significant fraction of the basic research support to the university, government, and industrial scientific researchers who are the core of the Space Science and Applications Program.

Suborbital Research.

Despite continuing problems with our heavy-lift balloons in FY 1985, we successfully launched 39 balloons (out of 47 attempts) to support various observations in upper atmosphere science, astrophysical research, and solar physics. In FY 1986, we are making strenuous efforts to reduce the problems encountered last year and we plan to launch another 47 balloons. This effort will continue at approximately the same level in FY 1987. All but one of the 37 sounding rockets launched in FY 1985 were successful; we plan to launch 44 rockets in FY 1986 and about the same number in FY 1987.

A special highlight last year was the successful first flight of the new *Spartan* satellite, which was launched and retrieved by the *Space Shuttle* in July, 1985. Three more Spartan vehicles are now under construction. *Spartan 2* and *5* are both solar experiments. *Spartan 3,* is an ultraviolet imaging system.

The *Kuiper Airborne Observatory (KAO)*, a C-141 aircraft equipped with a 91-cm telescope, provides a unique capability to make astronomical observations above 91 percent of the Earth's atmosphere. This ability is especially important for observations in the infrared and sub-millimeter wavelength regions. The KAO normally flies about 80 flights a year, supporting investigations that are competitively selected by peer review. In 1986 the KAO will make an expedition to Australia to make infrared observations of Comet Halley and other astronomical objects that can only be seen from the southern hemisphere. On this expedition, the KAO will carry seven instruments that measure in wavelengths from the near infrared to the sub-millimeter region.

Research and Analysis.

Astrophysics. The importance of mission definition and instrument development activities supported by the Research and Analysis program was illustrated last year in the selection of second-generation science instruments for the *Hubble Space Telescope (HST)*. All of the detector systems used in the selected instruments were developed through detector development programs in Research and Analysis, and one detector system was further qualified in a rocket flight.

Planetary Exploration. Ground-based studies were expanded last year to support several flight missions in FY 1986 and later years. Extensive telescopic observations of Uranus continued last year to support the *Voyager 2* Uranus encounter. Observations were also made of Neptune, the next target for *Voyager 2,* in order to refine positional data for the planet, to obtain more information on Neptune's apparent rings, and to improve targeting for *Voyager 2's* encounter with the planet in 1989. The ground-based *International Halley Watch (IHW)* continues to coordinate an intensive world-wide observational effort aimed at Comet Halley to support and extend the data obtained by the fleet of spacecraft that will study the comet at closer range in March, 1986.

In FY 1986 and FY 1987, research efforts will be continued to prepare for the Voyager 2 encounter with Neptune in 1989, the launch of Galileo to Jupiter, the radar mapping of Venus by Magellan in 1988, and the exploration of Mars by the Mars Observer spacecraft in 1991. Instrument definition efforts will also continue for two possible future missions.

Earth Science and Applications. Research and Analysis efforts in geodynamics, land processes, ocean processes, atmospheric dynamics and radiation, upper atmospheric processes and tropospheric chemistry, and space plasma physics will be supported in FY 1987. We will also continue the interdisciplinary research program, initiated in FY 1985, to examine interacting physical, chemical, and biological processes that affect the Earth's environment on a global scale. Research in this program is currently focused in three areas: (1) understanding the origins and consequences of the recently discovered increasing trend in the atmospheric concentration of methane; (2) determining the extent to which changes are being made in climatologically important properties of the land surface; and (3) developing a better understanding of the input, transport, and fate of carbon in the oceans.

Microgravity Science and Applications. Ground-based research is continuing at five Centers of Excellence, and these efforts will continue to be supported in FY 1987. These Centers serve as an important focus for new ideas and for the dissemination of research opportunities and results. We will also continue to support ground-based facilities which duplicate, for short times, the microgravity environment of space. These facilities, such as drop tubes, drop towers, and aircraft, provide proof-of-concept experiment opportunities for both academic and commercial program participants.

Communications. Our efforts in communications research during FY 1987 will continue to focus on future high risk technology needs, such as the development of advanced modems for on-board switching and processing, and spectrum-efficient and monolithic microwave integrated circuit components.

The cooperative Mobile Satellite Technology Experiment program between NASA and industry will continue in FY 1987 to develop critical technologies for conserving scarce orbit positions and frequencies and to accelerate the introduction of this new commercial service in the U.S. An Announcement of Opportunity for this program was released in February, 1985, and a highly successful briefing was held for industrial representatives in November, 1985. In FY 1987, NASA will carry out the first operational tests of advanced mobile satellite equipment, using a tower and balloon to simulate a satellite and an electronically-equipped vehicle as the mobile terminal.

POTENTIAL FUTURE MISSIONS

In addition to our current flight missions and supporting activities, the Space Science and Applications program continues to support advanced studies of possible future missions in order to define, select, and plan missions that are both scientifically exciting and cost-effective. I would like to describe briefly some of the more exciting candidate missions for the future.

ASTRONOMY AND ASTROPHYSICS.

The main thrust of our future missions are studies of the Great Observatories that are needed in space to complete our coverage of the entire electromagnetic spectrum. After launch of the Hubble Space Telescope (HST) and the Gamma-Ray Observatory (GRO) the Advanced X-ray Astrophysics Facility (AXAF) and the Space Infrared Telescope (SIRTF) are being planned to view critical wavelengths that are inaccessible to us: the X-ray region and the infrared. AXAF will be a major international observatory for X-rays that are generated by some of the most energetic and mysterious objects in the universe: black holes, quasars, and the cores of galaxies. During 1985, definition studies for the observatory continued and definition studies for the instruments were begun. As part of the technology program for the AXAF mirror assembly, the angular resolution and sensitivity of AXAF were successfully demonstrated. SIRTF will provide the critical tool needed for detailed studies of the infrared universe. During 1985, the SIRTF science working group was formed and development of the instrument technology was begun.

We will also continue to develop the technology for Gravity Probe-B (GP-B), a spacecraft which if ultimately approved for flight will perform an entirely new test of Einstein's General Theory of Relativity. The technology components for these experiments have been successfully developed, and we now plan to investigate how the components work together as a system. In FY 1987, we expect to complete the definition of prototype hardware that will provide the basis for a possible future on-orbit test aboard the Space Shuttle.

PLANETARY EXPLORATION

During FY 1986, study efforts are being continued to identify and characterize possible future planetary missions and to identify technology developments needed to support them. Current studies are based on recommendations of the Solar System Exploration Committee (SSEC), which recommended in 1983 a "Core Program" of planetary exploration for the next decade and beyond. This recommendation included the use of two new classes of spacecraft: Planetary Observers for inner solar system missions and Mariner Mark II spacecraft to explore the outer solar system.

The Planetary Observer series was initiated in FY 1985 with the Mars Observer mission. During 1985, several candidates for the second planetary mission were studied: a Lunar Geoscience Orbiter (LGO) to globally map the Moon and to search for frozen water near the lunar poles; a Near-Earth Asteroid Rendezvous (NEAR) to study the scientific problems and to characterize the resource potential of one of several asteroids that repeatedly approach the Earth; and a Mars Aeronomy Observer (MAO) to study the upper atmosphere of Mars and the interaction of the solar wind with the martian environment.

The first Mariner Mark II mission recommended by the SSEC is a Comet Rendezvous/Asteroid Flyby (CRAF) mission that would fly past an asteroid and then rendezvous with a comet for a long period of observation and study. The CRAF spacecraft design is modular and can be readily adapted for subsequent planetary missions. One possible Mariner Mark II follow-on to CRAF is a Saturn orbiter that would carry a probe to penetrate the atmosphere of Saturn's largest moon, Titan. During 1984 and 1985, NASA studied this mission (named Cassini) in cooperation with the European Space Agency (ESA), developing a mission concept in which the Mariner Mark II Orbiter would be mated with an ESA-developed Titan probe to form a single mission.

EARTH SCIENCE AND APPLICATIONS

The Earth System Science Committee (ESSC) was formed in FY 1985 at NASA's request to define a comprehensive research plan for study of the Earth as a whole from the vantage point of space. The research plan would encompass a wide range of related disciplines --- geology, geophysics, oceanography, biology, and atmospheric sciences. The initial report of the ESSC will be published in early 1986. We are also continuing to study the concept of Global Habitability and its relation to the proposed International Geosphere Biosphere/Global Change Program, which has recently been endorsed by the National Academy of Sciences and is now undergoing study by the International Council of Scientific Unions.

Based on the recommendations of the Committee of Earth Sciences of the National Academy's Space Science Board, we are studying two missions for the near-term future. The Geopotential Research Mission (GRM), to measure the Earth's gravity and magnetic fields with unprecedented accuracy and resolution, and the Magnetic Field Explorer (MFE) to repeat the global magnetic field mapping carried out by the Magsat spacecraft in 1979. MFE will provide highly precise global information about how the Earth's magnetic field is changing with time.

SPACE STATION

In 1984 NASA established the Task Force on Scientific Uses of the Space Station, as part of the NASA Advisory Council, to provide advice on how to optimize Space Station capabilities for Space Science and Applications activities. Last year, this Task Force, headed by Prof. Peter Banks of Stanford University, participated in several meetings with the Space Station Office and carried out its second summer study of scientific issues relating to the space station.

It is already clear that our future Space Science and Applications programs can benefit in major ways from the establishment of a permanent manned Space Station in the 1990s. The Space Station Program can provide such important capabilities as pressurized laboratory modules, servicing operations, workshop facilities, attached payload accommodations, the staging and launch of deep-space missions, and the support of polar platforms for Earth observations and co-orbiting platforms for astrophysics. During the past year, we continued several planning studies to understand the full potential of these new capabilities for our programs, to define the changes that they will make in our operations, and to generate detailed requirements for the Space Station. In addition, the Office of Space Science and Applications is working closely with the Office of Space Station to define and present our requirements in more detail. We participated actively in the first two Requirements Update Reviews held in July and November 1985, and the Interface Requirements Review (IRR) in January, 1986, and we look forward to a continuation of these cooperative discussions in the next year.

Other planning efforts related to the Space Station continue both inside and outside of NASA. During FY 1986, the Space Science Board (SSB) of the National Academy of Sciences continued its study to explore long-term future directions in Space Science and Applications; this study will take into account the capabilities that the Space Station can provide during this period. Preliminary studies have also been started within NASA to examine possible major space science activities that could be done after establishment of the Space Station, using the support that it could provide. Two possible efforts are the establishment of a Lunar Base and a manned mission to Mars. We will continue to be involved in these studies during the coming year; in particular, we are providing input about possible science activities that would be part of such a major undertaking.

In the era of the Space Station, new communications developments will be possible. Satellite design will no longer be limited in size and power, and on-board computer processing will be readily available. These factors will combine intersatellite laser links and large multibeam antennas, needed to develop geostationary platforms.

In the Astrophysics area, the most important capability that the

Space Station can provide is the servicing of orbiting spacecraft and instruments. Other priorities include: use of co-orbiting platforms to complete our program of Great Observatories with the Advanced X-Ray Astrophysics Facility (AXAF), and the Space Infrared Telescope Facility (SIRTF) and the use of the Space Station to support attached payloads, such as the Advanced Solar Observatory (ASO) and the Cosmic Ray Nuclei Experiment (CRNE).

In Planetary Exploration, the major focus for near-term Space Station activities is the development of an Astrometric Telescope Facility (ATF) that would be operated as an attached payload to search for other planetary systems. Precise measurements of the small motions of neaby stars, carried out over 10-20 years can detect planets as small as Uranus and Neptune around other stars. This data will provide our first statistical survey of the existence of other planetary systems in our immediate stellar neighborhood, and is essential to any effort to understand how the solar system formed. The Space Station can also support the collection of cosmic dust particles for detailed analysis of this exciting and little-studied form of solar system matter.

Studies on the later use of the Space Station have identified several valuable functions to support planetary science, including development of a dedicated planetary experiment laboratory to perform unique experiments in microgravity; the support of major planetary missions such as sample returns from Mars and a comet; and the support of dedicated co-orbiting instruments for planetary astronomy studies.

In Earth Science and Applications the major emphasis is on planning and development of the Earth Observing System (EOS), which will be deployed in the 1990s to provide the observational and data management systems needed to make detailed, cooperative, and long-term observations of global processes occuring at and above the Earth's surface. Current plans envision that the EOS instrument packages will be placed on Polar Platforms of the Space Station; the instruments will be designed for on-orbit servicing, augmentation, and replacement.

The Microgravity Science and Applications Program is aggressively pursuing the development of plans for Space Station utilization. The Space Station pressurized module will make possible ambitious long-term research projects which utilize low gravity.

Experiments will be conducted in a wide range of areas, including electronic materials and biotechnology.

The Life Sciences program will use the Space Station to conduct investigations on human physiology and various animal experiments related to health and safety of crew in long duration space flight as well as investigations in fundamental biological research and Closed Environmental Life Support Systems (CELSS).

CONCLUSION

The FY 1987 budget that we propose will continue the long tradition of achievement that the Science and Applications program has established in many diverse fields --- understanding the universe, learning about the Earth as a planet, and developing new and valuable applications of space. It will continue our essential ground-based supporting activities, move forward on the development of previously approved missions, and initiate the TOPEX mission. The FY 1987 budget will provide for measured progress in the science and applications disciplines. We are working to continue the outstanding efforts of the past, we will move forward on the development of current missions, we will actively plan important and exciting missions for the future, and we will preserve the science research base that is critical to maintaining U.S. leadership in space.

OFFICE OF SPACE SCIENCE AND APPLICATIONS
FY 1987 BUDGET REQUEST
(DOLLARS IN MILLIONS)

	FY 1985 BUDGET	FY 1986 OPER PLAN	FY 1987 REQUEST*
PHYSICS AND ASTRONOMY – TOTAL	677.2	569.3	539.4
HUBBLE SPACE TELESCOPE DEVELOPMENT	195.0	125.8	27.9
GAMMA RAY OBSERVATORY DEVELOPMENT	117.2	85.3	51.5
SPACELAB PAYLOAD DEVELOPMENT AND MISSION MANAGEMENT	105.4	89.4	115.1
EXPLORER DEVELOPMENT	51.9	48.2	56.7
MISSION OPERATIONS AND DATA ANALYSIS	109.1	111.7	172.7
RESEARCH AND ANALYSIS	39.9	49.0	51.1
SUBORBITAL PROGRAMS	58.7	59.9	64.4
PLANETARY EXPLORATION – TOTAL	290.9	353.6	323.3
GALILEO DEVELOPMENT	58.8	64.2	–
ULYSSES	9.0	8.8	–
MAGELLAN	92.5	120.3	66.7
MARS OBSERVER	13.0	33.8	62.9
MISSION OPERATIONS AND DATA ANALYSIS	56.1	67.0	130.2
RESEARCH AND ANALYSIS	61.5	59.5	63.5
LIFE SCIENCES – TOTAL	62.3	66.1	74.7
FLIGHT EXPERIMENTS	27.1	32.1	36.7
RESEARCH AND ANALYSIS	35.2	34.0	38.0
SPACE APPLICATIONS	374.1	487.5	526.6
SOLID EARTH OBSERVATIONS			
SHUTTLE PAYLOADS	12.1	21.8	21.6
GEODYNAMICS	29.9	30.0	32.1
RESEARCH AND ANALYSIS	15.6	19.1	20.4
SUBTOTAL	57.6	70.9	74.1
	BUDGET	OPER PLAN	REQUEST**
ENVIRONMENTAL OBSERVATIONS			
INTERDISCIPLINARY RESEARCH AND ANALYSIS	1.0	1.0	1.1
UPPER ATMOSPHERE RESEARCH AND ANALYSIS	31.0	31.1	33.4
OCEANIC PROCESSES RESEARCH AND ANALYSIS	19.4	19.5	20.8
ATMOSPHERIC DYNAMICS/RADIATION RESEARCH AND ANALYSIS	28.5	28.7	30.9
SPACE PHYSICS RESEARCH AND ANALYSIS	16.7	16.8	18.0
SHUTTLE PAYLOADS	7.8	5.3	12.0
TETHER PAYLOADS	3.0	4.3	1.0
EARTH RADIATION BUDGET EXPERIMENT	8.1	1.9	–
MISSION OPERATIONS AND DATA ANALYSIS	29.5	35.0	33.6
UPPER ATMOSPHERE RESEARCH SATELLITE MISSION	55.7	114.0	152.2
SCATTEROMETER	12.0	14.0	35.9
OCEAN TOPOGRAPHY EXPERIMENT	–	–	29.0
SUBTOTAL	212.7	271.6	367.9
MATERIALS PROCESSING IN SPACE			
RESEARCH AND ANALYSIS	11.7	12.1	12.9
MATERIALS EXPERIMENT OPERATIONS	15.3	18.9	31.0
SUBTOTAL	27.0	31.0	43.9
COMMUNICATIONS			
RESEARCH AND ANALYSIS	9.1	10.4	14.0
SEARCH AND RESCUE	2.4	1.1	1.0
TECHNICAL CONSULTATION AND SUPPORT	2.9	2.1	3.2
EXPERIMENT COORDINATION AND OPER. SUPPORT	1.2	0.9	1.3
ADVANCED COMMUNICATIONS TECHNOLOGY SATELLITE	45.0	81.9*	–
SUBTOTAL	60.6	96.4	13.5
INFORMATION SYSTEMS	16.2	17.6	21.2
TOTAL OFFICE OF SPACE SCIENCE AND APPLICATIONS	1404.5	1476.5	1464.0

*RESCISSION OF ACTS HAS BEEN SUBMITTED TO CONGRESS

**DOES NOT REFLECT IMPACT OF LAUNCH DELAYS RESULTING FROM LOSS OF CHALLENGER

QUESTIONS OF SENATOR GORTON AND THE ANSWERS

FY 1987 Budget and Likely Reductions

Question 1: The only budget action to date is that of the Senate Budget Committee, whose resolution assumes a freeze of NASA's FY 1987 budget at the level of the FY 1986 appropriation. If this were enacted, NASA would have $360 million less than the budget request provides. What would be the most likely and immediate effects of such a reduction on the Space Science and Applications programs?

Answer 1: Senate Budget Committee proposal:

- freezes NASA at post-Gramm-Rudman-Hollings level of $7.3 billion from FY 1986-FY 1989

- corresponding freeze for OSSA is $1,473 million or slightly above FY 1987 President's Budget request for FY 1987

- FY 1987 budget includes no funding for ACTS in FY 1987 or the out-years

- provides no flexibility for dealing with Challenger impacts

- implies all inflation would come out of program level

- assumes no new-starts for FY 1987-FY 1989

- ACTS reinstatement without additional funds would detrimentally impact other flight projects in OSSA budget

Advanced Communications Technology Satellite (ACTS) Program

Question 2: If the Administration's rescission request for ACTS is not approved, NASA will have spent between $150 and $200 million of total program cost of $360 million by the end of 1986.

What is the justification of cancelling ACTS at this point in its schedule?

Answer 2: It is the Administration's stated desire that the government avoid possible competition with the private sector and also that government subsidies for activities more appropriately and effectively undertaken by the private sector be minimized.

Question 3: I understand that the Department of Defense has just decided to place a laser experiment on the ACTS satellite, an investment of at least $75 million. Does DOD support the termination of ACTS?

Answer 3: I have had no indication from the DOD of any desire to see ACTS terminated.

Question 4: If ACTS were terminated, how would this affect our future position in the world telecommunications market--would we be conceding an identifiable and potentially lucrative segment of this future market?

Answer 4: If the technology is not developed by the private sector, yes, we would be conceding a segment of the future market most likely to the rapidly expanding European and Japanese telecommunications industries.

Galileo and Ulysses Missions - Radioisotope Thermoelectric Generators (RTGs)

Question 5: Could you describe the launch options under consideration for the Galileo and Ulysses missions?

Answer 5: Options under consideration for Galileo are a December 1987 Delta Vega and a January 1989 Delta Vega launch. For Ulysses, we are principally focusing on an August 1988 launch.

Question 6: When will the Interagency Nuclear Safety Review Panel submit its Safety Evaluation Report to the White House for launch approval of the Galileo and Ulysses missions?

Answer 6: No firm date for submission of the Safety Evaluation Report (SER) to OSTP has been established. However, we are scheduling all our additional analysis and test activities to permit submittal of the SER in early 1987.

Hubble Space Telescope

Question 7: What major technical challenges remain for the Space Telescope program?

Answer 7: The major technical challenges that remain for the Space Telescope program are:

- O Completion of Assembly and Verification
    - Includes activity at Lockheed, and when STS launches resume, at Kennedy Space Center.
    - Assembly is nearly complete (flight solar arrays and aperture door remain unattached).
    - Thermal/vacuum simulation remains as major step in verification process. Involves prolonged exposure to space vacuum levels and orbital temperature extremes. Complete in summer, 1986.
- O Maintain launch readiness by testing and correction of discrepancies.
- O Transportation to Kennedy, in environmentally controlled conditions, 3-4 months prior to launch.
- O Launch and orbital insertion
    - Deployment of appendages (solar arrays and antennas) and power-up of systems.
    - Activation of science instruments and alignment of telescope optics.

  - Checkout of spacecraft support systems.

- O Early evaluation on orbit to verify performance
  - Pointing and tracking.
  - Performance of optics.
  - Instrument Performance
  - Observational efficiency.

Question 8: What do you estimate to be the annual operations cost for the Space Telescope, as well as the annual Maintenance and Refurbishment (M&R) costs?

Answer 8: Assuming launch in late 1987, FY 1988 will begin our first year of post-launch operations. Mission operations and Science Institute staffs will be brought up to operational levels, and funding for science research programs and the planned maintenance missions will be stabilized at levels commensurate with steady state operations. Funding for the advanced science instruments will continue in order for replacements to be available when older instruments fail. These costs are included in the M&R category. In order to meet these requirements, our current estimates indicate that annual HST Operations cost for FY 1988 to FY 1992 will be approximately $75-90 million and M&R cost will be approximately $65-88 million real year dollars.

Space Science and the Space Station

Question 9: The March 1985 report of the Task Force on Scientific Uses of the Space Station states that NASA has done little to enhance its Spacelab and attached shuttle payloads activities in preparation for the Space Station.

Do you believe, as the report states, that NASA has not adequately enhanced these activities, and if so, how do you intend to do so, given our current and expected future launch capabilities?

Answer 9: We believe that our shuttle attached payloads activities will adequately prepare us for Space Station operations. Our major thrust is a transition to the dedicated discipline concept in which our payloads will consist of clusters of complimentary sets of single discipline instrumentation with highly focused objectives, as opposed to broad collections of multi-disciplinary instrumentation which characterized our early Spacelab missions. Such an approach is consistent with the way we want to do business on the Space Station. The Astro-1 ultraviolet astronomy facility, which was scheduled for the next flight after STS 51-L, is a good example of the dedicated discipline concept.

We are surveying our inventory of instrumentation to identify candidates for Space Station. We have not started modifying or enhancing payloads for Space Station because we feel it would be premature to do so until Space Station interfaces are better defined.

TOPEX

Question 10: Concerning the one new start in the FY 1987 request, how much below the request of $29 million could TOPEX operate on and still meet its scheduled launch in mid-1991?

Answer 10: The Ocean Topography Experiment has undergone an extensive review process in order to determine the resources which would be required to complete the presently defined satellite and sensor development efforts. It is essential that $29 million be provided in FY 1987 to initiate the contracts for sensor and satellite system design and fabrication. Any significant reduction will result in a delay in the planned launch date.

Question 11: What would be the likely consequence if the new start for TOPEX were delayed a year--would the French choose to carry out their parts of the program alone?

Answer 11: The French are considering the flight of their Poseidon instruments on SPOT if the U.S. TOPEX mission does not become a reality. We believe that if TOPEX is delayed beyond FY 1987 the French will proceed independently. A delay at this time would not only threaten the French collaboration but would impact the other international collaborations planned for TOPEX. TOPEX will pay an important role in the World Ocean Circulation Experiment and the Tropical Oceans and Global Atmospheres experiment. Such a delay would also shorten the overlap of TOPEX with the flight of the European ERS-1 satellite and the Navy's N-ROSS satellite with its NASA Scatterometer.

International Solar Terrestrial Physics (ISTP) Program

Question 12: When do you anticipate a new start request for the spacecraft that will support U.S. participation in the International Solar Terrestrial Physics Program?

How many spacecraft will this request support, and how much will this spacecraft development cost?

At what point would it be too late to initiate the development of these U.S. spacecraft in order to coordinate this effort with the spacecraft development of ESA and Japan?

Answer 12: Presently, the Office of Space Science and Applications (OSSA) is conducting an effort to provide U.S. instruments to the ESA SOHO and CLUSTER as well as the Japanese GEOTAIL spacecraft. This Collaborative Solar Terrestrial Research effort is funded from a combination of advanced technology program and Solar Terrestrial Instrument Development funds as indicated in the FY 1987 budget. The development phase of the Japanese GEOTAIL mission has begun and the ESA Scientific Program Committee has approved initiation of the definition phase for the SOHO and CLUSTER missions in early 1987.

OSSA is presently reviewing the possibility of conducting a Global Geospace Science (GGS) Program which could involve as many as three U.S. spacecraft. This is presently under consideration as a potential FY 1988 new start candidate. Different options are presently under consideration to determine if other spacecraft flight opportunities could be utilized to meet the GGS scientific objectives. Depending upon the number of spacecraft, present estimates of the development effort are approximately $250-400 million (including spacecraft, instruments and ground system).

Significant scientific benefit would be achieved by conducting GGS during the Ulysses and UARS extended missions in the 1992/1993 timeframe, by combining GEOTAIL with the GGS missions in 1993 and by closely coupling the CLUSTER, SOHO and GGS operations in 1994-1995 to complete the ISTP objectives. An FY 1988 new start is desirable to achieve the phasing of all of these complementary missions. The existence of the GGS missions in 1992 will enable the Japanese to achieve the full set of GEOTAIL mission objectives. GEOTAIL is targeted for a March 1991 launch.

Solar Optical Telescope

Question 13: In your statement, you mentioned that even though there is no funding in the request for the Solar Optical Telescope, NASA will still examine the program for future flight opportunities.

How distant into the future is such an opportunity likely to occur, and does this program retain its validity indefinitely?

Answer 13: Goddard Space Flight Center (GSFC) and the science community are currently studying a range of alternative programs in which the scientific scope and budget requirements are substantially reduced, but where the most crucial scientific objectives of the Solar Optical Telescope are, to a large measure, retained. Our current assessment leads us to anticipate a new shuttle program (High Resolution Solar Observatory) with a reduced optical size (100 cm primary mirror compared to 130 cm for SOT) to give very high (0.13 arc seconds compared to 0.10 arc seconds) spatial resolution and operating only in the visible region. The most critical quantitative observations of solar velocity and magnetic field structures will thus be preserved.

We anticipate that the smaller telescope system will permit its development more in the mode of a major item of scientific instrumentation rather than in the mode of a major facility-class system. Extensive participation of the science community through a Guest Investigator Program will be retained.

We will also explore significant foreign participation in developing the scientific instrumentation.

Budget estimates for the new program will be available this summer for potential inclusion in the NASA budget for FY 1988.

Microgravity Research

Question 14: What is the likely effect of the suspension of shuttle flights and the future constrained launch capability on flight opportunities for microgravity research experiments?

What options are being considered to ensure that microgravity research does not suffer over the next few years?

Answer 14: The Microgravity Science and Applications Program depends heavily on shuttle flights to attain its research objectives; therefore, the current suspension of shuttle operations is certain to delay and affect the research program. To minimize this effect, and to take maximum advantage of this shuttle down time, the following efforts are under consideration:

1. Retain the key investigator base and expand the Research and Analysis program to prepare for the resumption of flight operations. Careful and complete ground research is an absolute necessity for understanding flight results.
2. Increase the emphasis on, and usage of, ground-based facilities (drop tubes, drop towers, and aircraft) which simulate the microgravity environment, to allow for continuation and publication of basic research results.
3. Accelerate the development of "second generation" equipment, to insure the most effective use of flight opportunities when STS flights resume. The majority of the existing experiment apparatus is modified rocket hardware, which was designed for five (5) minutes of operation (not 5-7 days of reliable usage) and, furthermore, does not take advantage of the current state-of-the-art in instrument technology.

Planetary Exploration

Question 15: When do you anticipate a new start request for the Comet Rendezvous/Asteroid Flyby (CRAF) mission, and what will be the target comet and asteroids?

Answer 15: We anticipate requesting a new start for the Comet Rendezvous/Asteroid Flyby (CRAF) mission in a future budget. The planned mission could be launched in 1992 by a shuttle/Centaur and would flyby two asteroids (1415 Malautra and 46 Hestia) enroute to a rendezvous with the comet Tempel 2 in December 1996. The launch date and specific comet are dependent on the new start date.

Extended Duration Orbiter

Question 16: According to a NASA report prepared at the request of this Committee, your office and that of Space Flight and of Space Station are reviewing the needs for an extended duration orbiter. What have you learned and concluded in this review? Does the agency still believe that the costs of extending the on-orbit stay time of an orbiter outweigh the benefits?

Answer 16: We have learned that an extended on-orbit stay time capability for the fleet, while attractive to many disciplines, is very expensive and due to its weight (6,000 lbs) not beneficial to long module Spacelab flights. However, we will continue to evaluate future requirements in this area.

Long Duration Exposure Facility (LDEF)

Question 17: LDEF was launched in April 1984, with an expected on-orbit stay time of one year, yet it has not been retrieved.

What assurances are there that LDEF will be retrieved in 1987, as you have indicated in your testimony?

What mission requirements, other than the Heavy Nuclei Collector, exist for LDEF, and when are they scheduled?

Answer 17: In the last official NASA baseline manifest (November 1985), LDEF was scheduled for retrieval in September 1986. The post-accident environment has put the manifesting process in turmoil, but based on existing priorities it appears that LDEF will not be retrieved for several years.

In OSSA, there are no current plans other than to convert LDEF into the Heavy Nuclei Collector.

Future Programs

Question 18: What new start candidates will be considered for FY 1988? FY 1989?

Answer 18: Leading candidates for consideration as potential new starts in future budgets are (not in priority order):

- Global Geospace Science
- Comet Rendezvous Asteroid Flyby
- Advanced X-ray Astrophysics Facility
- Geopotential Research Mission Lunar
- Geochemical Orbiter

Question 19: When do you intend to conduct the shuttle test of the Gravity Probe-B mission, and would a shuttle test automatically assume that the Gravity Probe-B free-flyer would be flown also? If so, how soon after the shuttle test would the free-flyer be flown?

Answer 19: NASA continues to study the feasibility of testing Einstein's General Theory of Relativity with the Gravity Probe-B (GP-B) experiment. In order to maximize the probability of success, the GP-B program will be implemented in two stages; an engineering development program and a freely orbiting science mission which may evolve out of the successful engineering program.

The GP-B engineering development effort has been designed so that decision gateways are achieved before the next development phase begins. This staged approach permits NASA to fully understand the technological accomplishments of the past phase and the challenge of the new phase before committing agency resources. Thus, each phase depends on the success of the previous phase. The free-flyer mission commitment then depends on the successful completion of the GP-B development phases.

NASA is now actively pursuing the engineering development program. The engineering development effort will be broken into a Definition Phase, Design Phase, Fabrication Phase, and Integration and Test Phase. During the Definition Phase now underway, prototype hardware will be designed and tested and solutions to complex technical problems will be refined. A ground unit will be used to resolve technological problems associated with the integration and operation of the total system. A possible future shuttle test flight would validate critical experiment requirements and environmental parameters in an integrated experiment system. The activities in FY 1987 are designed to verify the entire GP-B instrument design and provide the information necessary to decide if we should enter into the next phase.

Spartan Program

Question 20: What are your plans to replace the Spartan payload and the Spartan Carrier and Support Structure that were lost in the Challenger accident?

Answer 20: We are committed to the Spartan program and have about ten selected scientific instruments under development by universities and governmental research groups. We are studying methods of carrying out the program in a timely manner, considering the likely opportunities available on the STS. Possibilities include an additional Spartan Flight Support Structure and Release and Engagement Mechanism which will permit two scientific missions on a single STS flight.

Replacement of Galileo II (CV-990) Research Aircraft

Question 21: What is the total replacement cost of the Galileo II research aircraft, how much do you intend to allocate within the FY 1987 budget for this effort, and when will the replacement aircraft be operational?

In what ways will the replacement aircraft differ from its predecessor--will it offer any new capabilities and will lack certain capabilities that its predecessor had?

Answer 21: Early this year, a DC-8 was acquired to replace the destroyed Galileo II (CV-990) research aircraft. The basic airframe, which was acquired for about $4 million, is being upgraded to meet current noise, performance and safety standards. This upgrading includes, among other things, retrofitting of the engines at an estimated cost of about $16 million. In addition, the aircraft will receive other special modifications--e.g. installation of consoles, instrument ports, power distribution system, etc., so that it will meet our needs as a research facility. The total cost for the upgraded aircraft is under review; however, total expected costs are in the vicinity of $35 million. This estimate does not include development of flight experiment hardware.

We expect to start operational flights in CY 1987. The DC-8-72 has additional carrying capability (about 30,000 lbs.) can fly longer distances (about 7,000 miles), and will satisfy the latest FAA noise abatement requirements. The CV-990 had less capability, flew shorter distances, and had to use military landing fields because of noise and smoke from the engines.

Land Remote Sensing

Question 22: Title V of the Land Remote Sensing Commercialization Act of 1984 provides guidelines for the dissemination of federal experimental data sets. The intent of the guidelines is to allow maximum utilization of the data without undermining the commercial viability of private land remote sensing systems. How has NASA carried out these guidelines and do you believe that Title V unduly restricts the utilization of experimental data?

Answer 22: NASA has carried out these guidelines by restricting the use of remote sensing experimental data to use by federally funded R&D investigation. Two examples of the implementation of these guidelines are the dissemination and use of the Large Format Camera (LFC) and Spaceborne Imaging Radar-B (SIR-B) data. Both systems flew aboard STS-41G in October 1984. In the case of the LFC data, it was delivered to the EROS data center for distribution to federally funded investigators. In parallel, the data has been sold in accordance with Title V. The purchaser of the data, Martel Laboratories, Inc. is embarked on a vigorous marketing campaign. The data from SIR-B has been distributed to the investigators selected by NASA in accordance with the SIR-B Announcement of Opportunity. Upon completion of processing, the data is being archived at the National Space Science Data Center (NSSDC) at Goddard Space Flight Center, Maryland. The NSSDC will be the distribution center for future federally funded R&D efforts. The sale of the SIR-B data set per Title V is currently being considered at NASA.

We recognize that Congress's main concern about the use of experimental data is based on avoiding competition with private sector activities and we concur with this policy. Nevertheless, the provisions of Section 502 as currently worded and interpreted, hamper the Federal Government in providing access to experimental data to the non-government funded research and development and user communities in a timely fashion. In some cases, these data may not have economic value. NASA believes it is very important to all potential users of land remotely-sensed experimental data that the research and development community have an early opportunity to evaluate the quality and potential of such data.

Such experimental data typically requires a minimum of two to four years after it becomes available to the investigator to evaluate and understand the potential for such data. The Goesat Committee in particular has taken a position that data from experimental remote-sensing programs is typically of an advanced type, with such limited coverage (one flight on the shuttle), that to consider it in competition with an owner/operator of the Landsat system is technologically inappropriate. They further feel that it is important for the knowledgeable end-user community to assess the potential use of the experimental data as an important step in evaluating the ongoing development of satellite remote-sensing.

Question 23: What is the status of the joint NASA/NOAA remote sensing national plan required by Public Law 98-365? Have delays in the plan resulted from differences in the views of NASA and NOAA, and if so, what are the major differences?

Answer 23: The document responding to the requirements of Public Law 98-365 is presently being printed and should be available for distribution within the next month. We are presently coordinating the transmittal of this publication with NOAA.

This first attempt to integrate a unified national plan has been extremely difficult due to the variety and independent nature of existing plans in the government and private sector. While NASA and NOAA's plans are not entirely congruent, we now have a collaborative approach to future implementation priorities and strategies through joint sponsorship of the Earth System Sciences Committee, the Space Applications Board of the National Research Council, the Eos/NOAA Polar Platform studies for Space Station utilization, etc. We have also produced for review a draft of a revised Basic Agreement which will delineate roles and relationships between NASA/NOAA and serve to strengthen the planning activities of both. As is typical of these activities, identified opportunities for advancement in this field far exceed the resources available for their complete and immediate implementation. Management processes to assure a balance between the enthusiasm of the science and applications community and the realities of economics necessarily take time to assure thorough analysis. These processes for this report were protracted due to the fact that this was the first time this program was put into an overall context.

Question 24: The Committee is aware that NASA works closely with the earth sciences community in order to determine future data requirements and the technologies and applications which best serve the requirements. What remote sensing technologies does NASA feel should be pursued in the forseeable future to provide for continued U.S. leadership in this area?

Answer 24: NASA's program in remote sensing instrument development is designed to improve the acquisition of information from space that will contribute to a better understanding of the physical, chemical, and biological processes occurring on Earth. In pursuit of this goal, we have established conceptual and developmental programs that include improvements in spatial and spectral resolution utilizing both active and passive techniques.

The present program includes development of experimental flight instruments such as an imaging spectrometer, an imaging radar, atmospheric constituent measurement devices for UARS and shuttle missions, solar radiation instruments, a wind scatterometer for flight on the Navy's NROSS, etc. Our present definition focus is to exploit the application of lidar systems to wind and atmospheric species measurements, improve altimeter technology for use in solid earth and ice research, improve gravity field measurements, and to examine the unique contribution expected of measurements in the millimeter and submillimeter range. In addition to these specific technology development programs, we are searching for means to achieve quantifiable measurements in global precipitation processes and measurements of key chemical radicals below the stratosphere/troposphere boundary.

We are reviewing our total program strategy and priority with the Earth System Sciences Committee to assure that our approach meets the needs of the science priorities being established as a goal for NASA's research program. The results of this review will be published as an implementation strategy with the overall recommendations to be submitted this fall.

Question 25: What is your view of the commercial potential of the recently launched French SPOT system and what effect will SPOT and other foreign systems have on the commercial viability of Eosat's commercial Landsat venture?

Answer 25: There is no question but that the introduction of SPOT and other foreign systems will erode the commercial viability of Eosat's Landsat venture. It is impossible, however, to say how extensive that erosion will be. Landsat is particularly vulnerable in areas where spatial resolution plays a key role, such as cartography. The SPOT resolution is 20m for the three colorbands, and 10m for the panchromatic imagery. Landsat has five spectral bands at 80m, six at 30m, and one IR band at 120m. In applications where multispectral information is required, Landsat still has the upper hand. As more advanced foreign systems are developed, however, the Landsat system will also have to advance or face further market erosion.

Senator GORTON. We will now hear from Drs. Townsend, Donahue, and Mason.

Dr. Townsend, we will start with you.

Again, as with other witnesses, your statements will be included in the record. Yours is not very long.

STATEMENTS OF JOHN W. TOWNSEND, JR., SENIOR VICE PRESIDENT, FAIRCHILD INDUSTRIES, INC.; THOMAS DONAHUE, CHAIRMAN, SPACE SCIENCE BOARD, NATIONAL ACADEMY OF SCIENCES; AND GLENN MASON, SPACE SCIENCE WORKING GROUP, ASSOCIATION OF AMERICAN UNIVERSITIES, DEPARTMENT OF PHYSICS AND ASTRONOMY, UNIVERSITY OF MARYLAND

Mr. TOWNSEND. I was just talking to Tom to make sure he did not have a squeeze because of his airplane.

Mr. Chairman and members of the committee, the space applications board of the National Research Council appreciates the opportunity to participate in these hearings. The board's functions are to help formulate the national program for practical application of space systems, to give independent advice to NASA and other agencies and to assist in broadening the understanding of industry, the universities, and the public in the practical applications of space technology.

The purpose of my testimony here is to provide the views of the board on parts of the fiscal year 1987 budget which pertain to applications programs. The attention will be directed to two programs, the advanced communications technology satellite, ACTS Program in the NASA budget, and the Landsat commercialization in the NOAA budget.

The board is very concerned about the proposed elimination of funding for these two programs. Support for these programs has been expressed in studies and publications by the board and in previous testimony to both the House and the Senate. Both programs relate to the commercial applications of space systems, a desirable and generally accepted national goal. Both programs are also in areas where the longstanding U.S. position of leadership is threatened by foreign encroachment.

With respect to ACTS, our support of this program is well known to the committee from our previous testimony. Two years ago we urged reinstatement of the flight test phase of this program. Last year we applauded the reinstatement, due in large part to the initiatives of this committee. This year, as a result of the budget constraints that must be considered by NASA, the satellite program has not been included in the budget.

The value of ACTS is twofold. First, the flight experiment will allow the technology developers opportunity to establish the performance of the advanced technology in a real prototype operational environment. Secondly, it will allow both service suppliers and users to experiment with the new technology so they can become familiar with and develop a confidence in its use and assess its performance and cost for their own particular application.

While the board recognizes the problems that must be resolved in the budgetary process over the next few years, it must support the ACTS Program. The objective of the program, to advance satellite telecommunications technology to meet the expected demand in the next decade by means of novel and improved processing and transmission techniques, is still valid. The board believes that Government must support this advanced high-risk technology because it is very much in the public interest. The technology, which will allow more efficient use of the frequency spectrum and of the geostationery orbital arc, is important for domestic governmental and industrial usage and for our international competitive position.

With regard to Landsat commercialization, the board's support of this commercialization is also well known to the committee from our previous testimony. The board's major concerns in the remote sensing program are described in a recently published report by the board. On the issue of the land remote sensing area we remain concerned about a number of issues.

One of these is a gap in the availability of Landsat data if a replacement for Landsat 5 is not available before that spacecraft deterioriates. Another is the probable lack of improved resolution in the land remote sensing data for some time in the future because advanced instrumentation may not be available. A third is the foreign competition from the French Landsat-type satellite SPOT which has better resolution intruments than Landsat and thus may well capture market position from the U.S. program.

Removal of support for Landsat commercialization in the NOAA budget for 1987 increases the urgency of these concerns. The board is aware that many other interests are also concerned about the removal of support of the commercialization initiatives from the fiscal year 1987 budget. As must be the case for many other parties, we are not yet aware of what the effects of deletion of part of the support will have on the program as envisioned by Public Law 98-365. That is the Land Remote Sensing Commercialization Act of 1984.

It is also not yet clear what the position of the commercial operator, EOSAT, will be regarding the effect of the deletion of the program. The position of the board is simply that the land remote sensing effort of the United States is already in rather serious difficulty, and that removal of the funding from the fiscal year 1987 budget will only make the situation worse.

Although the above part of my testimony pertains to programs eliminated from the President's budget, the board feels strongly that NASA's new start, TOPEX, is an excellent mission. It benefits both science and applications. Somehow we must find a way to allow a few new starts in NASA each year in spite of these current difficulties so that our country's Space Program will retain its leadership role in the future.

Mr. Chairman, the Space Applications Board appreciates the difficult task and the difficult choices that the Congress must face in the coming months concerning funding and appropriations for the next few years. We hope that our testimony here is helpful in your consideration of some of the issues.

Senator Gorton. Thank you. It certainly will be.

[The following information was subsequently received for the record:]

QUESTIONS OF SENATOR GORTON AND THE ANSWERS

Question 1. How will the suspension of Shuttle flights affect university space science and space applications research?

Answer. There is no question but that suspension of Shuttle flights will adversely affect university space science and space applications research. Materials research in the applications program will be very severely impacted because they have already been delayed a number of years and now there are no flight opportunities for research for possibly two years.

Question 2. During this period when no Shuttles are being launched, how can NASA most effectively utilize its Space Science and Applications resources to prepare for the resumption of Shuttle flights?

Answer. In both space science and applications advanced instrument funding would prepare for the future and would keep some of the groups going. Data analysis from previous flights should be liberally funded-again, to keep college and university teams together.

Question 3. Would a three-orbiter fleet adequately serve our nation's space science and applications programs? If not, what would suffer?

Answer. I do not believe a three-orbiter fleet could adequately serve our nation's needs. In the immediate future, space science and applications programs are likely to lose out on shuttle flights because of priorities. In the longer term, I do not believe we can build and service a space station with three orbiters.

Question 4. To what extent could the Space Science and Applications programs utilize expendable launch vehicles for missions and payloads previously manifested aboard the Shuttle? Would an ELV launch alter in any way the scope or capabilities of these missions and payloads?

Answers. Space science and applications programs could probably use ELVs for some missions, but the payloads would have to be reconfigured. However, this would apply only to those payloads that do not require the presence of a man in orbit.

Question 5. As a result of the Shuttle accident, do you think there are fundamental changes in NASA's Space Science and Applications operations that should be considered? For instance, should NASA consider making its spacecraft and payloads compatible with both the Shuttle and ELVs?

Answer. I am for a balanced launch capability between shuttles and ELVs. Those payloads that do not require the man in orbit should be configured for unmanned launch vehicles. Those that require man's presence obviously must use the shuttle.

Question 6. In your testimony, you stated that our nation's long-standing position of preeminence in satellite communications technology is threatened by foreign encroachment.

Could you be more specific about this particular threat, and how would the ACTS program enable us to maintain our position of leardership?

Answer. It is my belief that the European community and Japan pose a direct threat to our leadership in communications satellite technology.

Question 7. What indication is there that industry will develop these ACTS technologies, absent a government-sponsored ACTS program, and if industry were to do so, would it be soon enough to stay abreast of our foreign competition?

Answer. I do not believe industry will develop all of the ACTS technologies because of the large investment required and the risk element. Over a period of time I'm sure some of the technology would be incorporated in communications satellites but we are talking evolution, not a totally new capability like ACTS.

Question 8. Just what would we concede if we chose not to support the ACTS program?

Answer. I think we would concede utilization of the higher frequencies to the Japanese.

Question 9. Is NASA's Space Station program adequately accommodating the potential space science and space applications uses of the space station? If not, what changes should NASA consider?

Answer. Before the Challenger accident, I believe NASA's Space Station program was planning adequate accommodation of potential space science and space applications users. I am certain that the accident has set back some of this effort but there will be time.

Question 10. How might the scope and emphasis of NASA's Space Science and Applications programs be altered to enhance space science and space applications uses of the space station?

Answer. For most space science and for virtually all space applications, the polar platform is essential. This should be emphasized in NASA's planning.

Senator GORTON. Mr. Donahue.

Mr. **Donahue**. Mr. Chairman, thank you for asking me to appear here this afternoon at your hearing. You have my formal statement, I know.

Senator **Gorton**. We have, and it will be included in the record.

Mr. **Donahue**. Thank you. I realize it will be placed in the record, so I will just touch on some of the highlights in it, and spend most of my time on the matter of the greatest urgency in my opinion, and that is the meaning of the *Challenger* accident for the Space Science Program as a whole and for the Space Science Program in particular.

We recognize the very positive elements in this year's budget submission in a year in which fiscal stringency is the keynote. We certainly welcome the request for the new start for TOPEX, the ocean topography experiment, for the funds to support the ESA SOHO and Cluster missions and the Japanese tailwinds experiment, and for the ground systems study of the Gravity Probe B mission.

When you add to the scatterometer on the NROSS satellite and the upper atmosphere research satellite TOPEX, then you are getting well down the road toward carrying out the strategy that has been commended by the Committee on Earth Sciences of the Space Science Board to NASA for the exploration and understanding of the planet Earth. We are certainly very pleased that NASA is continuing to pursue the eventual flight of the Gravity Probe B mission. That mission addresses scientific issues of the very highest order, and it does so with challenging and innovative technology that represents the ideal kind of enterprise that we think the Nation's Space Science Program ought to be engaged in.

I would remark that with the unfortunate hiatus in the program caused by the *Challenger* accident, with the possible effects of Gramm-Rudman-Hollings in fiscal years 1986 and 1987, I hope that the Office of Space Science and Applications steps back and takes a very careful look across the board at its entire Space Science Program with nothing sacred, because the ground rules have changed now, and it is very important that we position ourselves so that we carry on the Space Science Program during this period of stress in a way that maximizes the yield of the program and assures that important elements in the program survive to be ready to be used when finally we begin to fly again after the effects of this accident are over.

As far as the loss of the *Challenger* is concerned, the present period of introspection, of course, is something we have to go through, and I certainly approve of the care with which that is being done. I am disturbed, however, by the kind of brooding mood of introspection and preoccupation with failure that we seem to be falling into.

And I am not sure that we have recognized what I believe is the most important lesson from the *Challenger* accident. For me the most important lesson is that since the early seventies this Nation has been trying to carry out a highly visible, prestigious national enterprise on the frontiers of technology, with a resource level so meager that one tragic accident has crippled the entire program, civil and military.

Since 1974, we in this room realize that the annual budget of the Civilian Space Program has remained almost constant at about $7.5 billion in constant 1986 dollars which is about a third of the peak funding level during the sixties when we were doing the Apollo Program. That reduction of a factor of 3 in the Space Program reflects a decision that was made at that time, at the time Apollo was ending, not to sustain a space program at the level of the one that had placed men on the Moon and returned them to Earth.

It also reflected a failure to identify any clear goals for the Nation's Space Program following Apollo. The result was the emergence of the space shuttle as a transportation system that was meant to be the sole national means of access to space. And it was expected ultimately to be economically self-sustaining. Corollary actions stopped procurement of expendable launch vehicles before the shuttle became a proven, reliable system. They prevented planning for the development of advanced unmanned launch systems, and they resulted in the construction of ambitious space science missions—I refer to Galileo and to Ulysses—that would cause concerns for safety and severely test the capability of the shuttle in its very first attempts to launch high priority science spacecraft.

This policy that deprived the Nation of its means to launch any major science payload for almost a decade has been devastating for space science. As a matter of the highest priority in a reenergized National Space Program to which a realistic level of support is dedicated, I strongly urge that we move rapidly toward the acquisition of a balanced fleet of launch vehicles that will provide assured access to space for all of the activities demanded of the National Space Program.

The characteristics of this launch system should be determined by assessing the needs and requirements of all potential users: Civilian and military, manned and unmanned, scientific and commercial

So, I would urge that a space transportation and launch system be expeditiously acquired that would allow human resources to be used where they are needed and can be most effective and allow unmanned vehicles to be the carrier of choice for other missions.

That concludes the summary of my statement, Mr. Chairman.

[The statement and questions and answers follow:]

STATEMENT OF THOMAS M. DONAHUE, CHAIRMAN, SPACE SCIENCE BOARD, NATIONAL RESEARCH COUNCIL, NATIONAL ACADEMY OF SCIENCES

Mr. Chairman, members of the subcommittee, ladies and gentlemen: Thank you for inviting me to appear here today. As you know, I am here as Chairman of the Space Science Board of the National Research Council. The Board is responsible for advising NASA and other elements of our government about science issues in the Nation's space program. As a result of that charge I have the pleasure of appearing here every year at about this time to discuss the implications of the President's budget request for space science. With respect to the President's budget submission for NASA, I have several comments. First, I think we all recognize the very unique budget situation with which we find ourselves this year. I must commend the Administration and NASA for putting forward a budget request that not only sustains FY 1986 appropriated levels, but recommends increases for selected programs as well. At a time when most federal agencies are facing a situation of significant cutbacks and program eliminations or reductions, it is indeed worth noting the positive support offered in the President's request for NASA in FY 1987. We are well aware of the gravity of our economic situation—a continuing deficit and the recent enactment of the Balanced Budget and Emergency Deficit Control Act as a method of dealing with it. To have recommended an increase for NASA in the context of this particular budget year represents, we believe, a certain optimism and foresight for the future.

Of course, we also understand that the President's budget request for NASA preceded the tragic explosion of the Shuttle *Challenger*. To assume that the effects of this event will not affect this and other year's budgets for NASA would be naive. We will be anxious to hear what specific changes will be recommended and how this will affect the future of the Space Science program. In the absence of any announced modifications to the budget request, however, let me turn to some of the specifics in the budget as it stands today.

The positive elements, and they are most welcome after the hiatus in new starts last year and at a time such as this when budget stringency is so prevalent, are the new start for the joint Ocean Topography Experiement (TOPEX) with the French, the request for support of the Japanese Tailwinds and European Space Agency (ESA) Solar Heliospheric (SOHO) and Cluster missions and the provision for funds to proceed with ground level systems testing of the Gravity Probe B mission.

TOPEX promises to measure the oceanic topography with high precision for a period of three years. These measurements will allow us to map the variable and the time-averaged surface geostrophic currents of the oceans, to measure the geocentric ocean tides, to observe ocean waves, study the interaction of storm waves with currents, and to investigate damaging storm surges in coastal regions.

I note that in order to use these measurements to obtain time-averaged ocean currents, those due to the general circulation of the ocean, it will be necessary to know the undisturbed shape of the ocean surface as it is determined by gravity alone, a figure known as the geoid. To obtain sufficiently accurate information about the gravity field special gravity-measuring satellites systems such as the Geopotential Research Mission (GRM) will eventually be needed. With the approval of TOPEX, the addition of the NASA Scatterometer to the Navy Remote Ocean Sensing System (NROSS), and the ongoing development of the Upper Atmosphere Research Satellite (UARS), the Environmental Observations program of NASA would demonstrate that it is well along toward implementing the strategy developed by the Space Science Board's Committee on Earth Sciences.

The request for support of the Japanese and ESA solar and space physics missions is a positive step toward increasing our understanding of the interaction of the Sun with the Earth's magnetosphere. The proposed SOHO spacecraft would be placed a the Lagrangian L1 point. It would measure the solar wing input to the magnetosphere and carry out a program in solar seismometry by observing oscillations in the solar surface that are caused by fundamental processes operating deep within the Sun. The multispacecraft Cluster mission would provide us with data concerning the morphology and small-scale structure of boundary regions between the solar wind and the magnetosphere, while Tailwinds simultaneously would investigate the interaction of the geomagnetic tail with the solar wind. The program, thus supported, would have validity and integrity in its own right, but of course it falls short of fulfilling all of the objectives of the International Solar Terrestrial Program which was recommended by the Board's Committee on Solar and Space Physics in its recent report as the first mission to be performed in an orderly solar and space physics program. In our view the implementation of the rest of this program with the three U.S. orbiting laboratories should be considered again in future budget exercises.

The Board has already expressed its enthusiasm for the ingenious proposal by the Stanford Group to detect the effect of the Earth's rotation on the geometry of nearby space. This gyroscopic experiment, known as Gravity Probe B, represents scientific technology at its most innovative and challenging. The results, whether as predicted by General Relativity or not, will be highly significant for the foundations of physical science. It is good to find that NASA proposes continued support for this exciting enterprise.

We recognize the practical difficulty of getting all that we would like in one year, particularly this kind of year, but the absence of the Comet Rendezvous and Asteroid Flyby (CRAF) mission from the list of those missions for which approval is being requested is disappointing. As you know, this is the mission recommended by the Solar System Exploration Committee to follow Magellan and the Mars Observer. It is the first that would require the new Mariner Mark II spacecraft. It is also the first mission designed to implement the program for studying primitive solar system objects outlined by the Board's Committee on Planetary and Lunar Exploration (COMPLEX). It is our understanding that proposal of this mission will be a budget issue next year. Since celestial mechanic regulates the time when missions like this must be launched we cannot delay indefinitely preparing for this mission if we are determined to begin the study of the primitive constituents of the solar system.

Now come the negative aspects of the proposed budget. First of these is the cancellation of the Solar Optical Telescope (SOT). The SOT program has been repeatedly endorsed by several National Academy of Sciences committees, most recently by the Board's Committee on Solar and Space Physics. It is not only critically important to the scientific objectives of solar physics, solar-terrestrial physics and space plasma physics, but also is the centerpiece of planning for the Advanced Solar Observatory—a complex of instruments for use on the space station.

The cancellation of SOT does not change the top priority objective of solar physics; i.e., the study of solar phenomena at high resolution levels approaching the spatial scales where the major physical processes occur. Either SOT needs to be reinstated or the solar physics community will have to assess whether it makes sense to proceed with a smaller telescope of reduced resolving power.

With the elimination of SOT and the effective decline, after adjustment for inflation, in the amount of support requested for level of effort and research and analysis (R&A) programs there is a clear reduction this year in the level of Space Science and Applications activity. An issue to be addressed is whether this is a temporary state of affairs or represents a reordering of priorities that will be felt also in the out years. The implications for the health of space science in the University community are very serious if the latter is the case. These categories of NASA support for science provide the bulk of the funding that insures the existence of a scientific infrastructure for NASA's flight programs outside of the NASA Centers. Hence that basic support structure is threatened. And what we are looking at here is not necessarily the worst of the news. We do not know what will be the impact of the loss of Challenger on January 28 on funding in FY 1986 and in FY 1987. We do not know whether the automatic reductions mandated by Gramm-Rudman-Hollings will occur in 1987 or not. Certainly, starting with this budget request as a base and projecting the effect of these other factors to the worst case would lead us to foresee a possible catastrophe for space science in the nation's universities. The question of balance between similar kinds of scientific research activities at NASA Centers and outside of them needs to be addressed in this context. One suspects that the highest priority at NASA would be to protect its own institutions. The Congress will have to decide whether such a course is the one the nation should follow.

Looking ahead at the impact the loss of Challenger and the delay in resuming Space Transportation System Operations will have on space science missions, the principal cause for concern relates to the Ulysses and Galileo missions. Since both go to Jupiter they must leave within a few days of each other during a window that recurs every thirteen months. The next opportunity will be early in the summer of 1987. It is certainly imaginable that the shuttle will not be back in operation at that time. Even if it should be, these spacecraft and their Centaur stages require modified orbiters to accommodate them. We lost one of these with the Challenger accident. It is my understading that only one of the other two is suitable for the required modification. Eventually one orbiter will be sent to the Western Test Range. So there is a question of how to make best use of the time while the shuttle is out of operation to make these modifications or find some other solution to this problem. Furthermore, the concern about the safety of launching Radioisotope Thermoelectric Generators (RTG) on shuttle has certainly not been alleviated by the accident. Obviously, there is a long series of other science missions waiting in the queue: Hubble Space Telescope, two planetary launches, the Gama Ray Observatory, the Upper Atmosphere Research Satellite, the Cosmic Background Explorer, the German Rosat mission previously scheduled to be launched before 1989. And in addition there is a long list of shuttle payload experiments, space Labs and Spartans——a total of 20 missions planned for 1986 and 1987. The delay and/or cancellation of science missions due to the grounding of the Shuttle fleet will be costly, both in terms of increases to the already strained science budget as well as the expense of providing the additional launch capabiliby required to carry out our national space program. Therefore, a key issue for the next 2-3 years will be the level of priority given to science in the revised STS manifest.

All of which forces me to return to a topic which I have visited often during the four years that I have been Chairman of the Space Science Board: the disastrous effect on space science that termination of expendable launch vehicles in favor of exclusive reliance on the shuttle for access to space has had. I hope that one lesson we learn from the tragedy of the flight of STS 51-L is that we must proceed—expeditiously—to develop a balanced fleet of launch vehicles for the space program. It has been demonstrated that it was a serious mistake to attempt to carry on the space program, which by its very nature should be agressive and bold, with meagre resources. It would be shortsighted not to set out to reacquire quickly at this time the flexibility that they offer. I am not arguing against a shuttle. Such a vehicle will clearly be needed to get back and forth to the space station. I am arguing for something else as well. There are lots of things that need to go into orbit that do not need to be conveyed there by a human driver. Let us use our human resources where they are needed and will be most effective and carry out the rest of our space program less expensively and with greater flexibility and security.

QUESTIONS OF SENATOR GORTON AND THE ANSWERS

Question 1. How will the suspension of Shuttle flights affect university space science and space applications research?

Answer. As you know the space shuttle is the only means now available to launch space science earth orbital, planetary or interplanetary missions. Without spacecraft in orbit there is no such thing as space science. So the university community that does space science is on hold while it waits for the resumption of shuttle flights, except for those that are involved in suborbital programs. All of those scientists waiting to analyze data from the Hubble Space Telescope, Galileo, Ulysses, COBE, GRO, and on and on are facing two year delays or worse in their programs. This is in addition to the long wait for the shuttle before January 28 after expendable launch vehicles were removed from the fleet for space science. The last major science launches were the Voyagers and Pioneer Venus in 1977 and 1978.

Question 2. During this period when no Shuttles are being launched, how can NASA most effectively utilize its Space Science and Applications resources to prepare for the resumption of Shuttle flights?

Answer. The impact of this delay can be moderated if NASA takes measures to capitalize on the flotilla of 20 operating scientific spacecraft that are still in space and to enhance funding for various elements of the research base programs. It is imperative that NASA exploit the opportunity to support important research in astronomy, planetary science, solar and space physics and earth science by encouraging the broadest possible use of the existing spacecraft, such as Voyagers and Pioneers. Where feasible, existing investigator teams should be supplemented by guest investigator teams. I have been scandalized to learn that some NASA managers are actually going in the other direction at this time and are planning to reduce support for existing spacecraft. It is just unthinkable that anyone should contemplate reducing the exploitation of the only flying assets we have got during this time when we are not able to launch any new spacecraft. It might not be a bad idea for this committee to consider prohibiting such foolishness and mandating full use of existing spacecraft during this emergency.

Similarly it is vital that NASA increase—despite Gramm-Rudman-Hollings—its SR&T programs at this time. This is necessary in order to keep research groups viable that would otherwise have been analyzing data from new missions in a short time. When I refer to GRH I mean that across the board cuts should not take a toll of Research and Analysis activity. In fact, it should be expanded. Laboratory investigations, suborbital programs, instrument development and theory should be encouraged at this time.

The Agency also should use this time to reevaluate its entire space science program. This should be done to insure the survivability of its program during the coming two years and to be prepared to accelerate as quickly as possible with a productive program once launches begin again. A lot of "givens" are no longer to be taken for granted. For example, consideration should be given to an accelerated Explorer program using expendable launch vehicles.

Question 3. Would a three-orbiter fleet adequately serve our nation's space science and applications programs? If not, what would suffer?

Question 4. To what extent could the Space Science and Applications programs utilize expendable launch vehicles for missions and payloads previously manifested aboard the Shuttle? Would an ELV launch alter in any way the scope or capabilities of these missions and payloads?

Question 5. As a result of the Shuttle accident, do you think there are fundamental changes in NASA's Space Science and Applications operations that should be considered? For instance, should NASA consider making its spacecraft and payloads compatible with both the Shuttle and ELVs?

Answers 3–5. The answer depends on how soon expendable launch vehicles could be developed for space science. As I said in my summary remarks and formal statement, space science needs to shift many—in fact most of its launches to ELV's at the earliest feasible time. It is true that Galileo and Space Telescope were designed so that neither could be launched by an existing ELV. I would go so far as to say in the future no science missions should be designed that can be launched only from the shuttle. The shuttle and people in space have their uses, but it does not make sense to use them in launch operations that could be handled by ELVs. Of course there are experiments that are designed to be carried out on board the shuttle or on a space station. I am not addressing these.

Question 6. Is NASA's Space Station program adequately accommodating the potential space science and space applications uses of the space station? If not, what changes should NASA consider?

Answer. So far NASA's Office of Space Station has been doing and admirable job of listening to and responding to the scientific community. It is imporatant that this posture be maintained in the crucial implementation phase of the program. I would warn against institutional arrangements that would exclude, reduce or minimize the participation of NASA Centers indentified with science, such as Goddard, in the program.

Question 7. How might the scope and emphasis of NASA's Space Science and Applications programs be altered to enhance space science and space applications uses of the space station?

Answer. Facilities such as Space Station should respond to the needs of their users and not the other way around. The Space Science Board has repeatedly insisted that the existence of the space station should not be allowed to alter the priority of missions that need orbits incompatible with Space Station. It is essential that the Space Station and other facilities such as ELV's be designed so that they can accommodate the widest possible range of user needs and not the other way around—user activities be designed to exploit the Space Station.

Question 8. According to your testimony, the Solar Optical Telescope is not only critical to a number of scientific disciplines, but it is also the centerpiece of planning for the Advanced Solar Observatory which will be a space station facility. Without the Sollar Optical Telescope, will there be no Advanced Solar Observatory—are there not other ways to develop the Advanced Solar Observatory?

Answer. The solar science community is in the process of defining a new facility to replace SOT. If it does its work well, what emerges should be an adequate precursor for the Advanced Solar Observatory, whatever that happens to be.

Question 9. You have raised the question of safety of the Radioisotope Thermoelectric Generators (RTGs) on the Galileo and Ulysses missions. What are the issues as you see them, and what are our other options? Should these missions be launched by unmanned vehicles?

Answer. In the case of Ulysses there is an adequate weight margin so that the RTGs can be shielded adequately. This should also be the case for Galileo if it is launched on a Vega trajectory late in 1987 from the shuttle. It is my understanding that there is no ELV, except perhaps the Proton, that could handle Galileo.

Senator GORTON. An eloquent and very precise statement. Thank you.

Mr. Mason.

Mr. MASON. Mr. Chairman and members of the committee, these are, of course, difficult times for the Nation's Space Program, with the tragic loss of the *Challenger* and its crew, the public investigation into the cause of the tragedy, and the uncertainty of when we will launch satellites again. In addition, we have the threat of massive budget cuts under the Gramm-Rudman-Hollings bill.

Throughout these difficult times, we should never lose sight of the fact that the Nation's future depends on space. We are a spacefaring nation destined to explore. Our long-term economic health and national security depend on our understanding space. As human beings we need to understand our place in the universe.

I represent the Space Science Working Group of the Association of American Universities, which is a consortium of 23 universities that are actively involved in space research. I would like today to comment on the proposed fiscal year 1987 space science budget, but cannot do so without also sharing with you the concerns we have about the consequences of the Gramm-Rudman-Hollings budget reductions. I will also argue that if it is expected to continue to play a vital role in the Nation's Space Program, the university space science community must be given priority in the near-term and long-term program and budget planning at NASA.

The university scientific community provides the backbone for the space science research in the United States. It is the source of new talent through the training of graduate students and post doctoral researchers. It is the major source of the fundamental scientific questions and new scientific instrument development. It provides the analysis and interpretation of mission results. Indeed, one of the basic tenets for why the United States conducts the space program is for the scientific breakthrough NASA makes to which the university scientific community is an essential participant.

However, the university space science community is a fragile enterprise. The number of viable groups that have survived through the recent years of budgets that have either barely or not kept up with inflation is minimal. We must assure that there is a continuity of funding to these groups so that they are not dissolved, never to be reassembled. Unless we take deliberate, well considered actions to protect the university space science community in these times of shuttle reprogramming and budgetary reductions, it will be irreparably damaged.

The *Challenger* accident was not only a personal tragedy to the Nation, but it will also have profound implications for the conduct of space science in the United States for years to come. Since the development of the shuttle, we have been dependent on it for the launching of major missions. The flight program thus is at a complete stop until the shuttle flies again or until alternative launch vehicles are provided.

Even when the shuttle flies again, we will have only a three-orbiter fleet to service the heavy demands of the military, commercial users, and the scientific community. The Ulysses and Galileo missions will not fly this May, and unless another shuttle is equipped, as was *Challenger*, to accommodate the Centuar rocket, it will be possible to launch only one of these missions in the next launch window in June 1987.

The launch of the space telescope and numerous Spacelab flights may be delayed as well. These disruptions will have a major impact on the budget of the Office of Space Science and Applications. Delays in the flight programs inevitably mean cost overruns. Contract and center personnel cannot be released from a project until the mission is launched.

Delays in the flight program also place an unusual burden on the already strained research and analysis budget for the Office of Space Science and Applications. These budget provide the basic support for all university space science research. With a delay in the flight programs, this funding takes on a new significance. The university groups that had anticipated support from flight programs can now only sustain their essential capabilities with research and analysis funding. We ask therefore that as you develop authorization legislation for the fiscal year 1987 NASA budget, that you consider the following principles:

Do not put the Space Science Program in double jeopardy. The Office of Space Science and Applications will already bear considerable cost for delays in shuttle flights. Do not also require that it contribute to the cost of replacing the fourth orbiter or to the development of alternative launch capabilities. We also ask that you give some priority to the research and analysis budgets that maintain the capabilities of the university space science community and indeed if possible to enhance these funds to provide alternative funding to that which was expected from flight missions.

The proposed fiscal year 1987 budgets for research and analysis would provide funding essentially at the fiscal year 1986 level, that is, the level prior to Gramm-Rudman-Hollings cuts. At the very least, in any reprogramming or amending of the budget, the research and analysis funds should not be allowed to fall below the proposed fiscal year 1987 level.

A continuing problem for the U.S. space science has been the lack of low-cost flight opportunities, a problem that has now been exacerbated by the loss of the *Challenger*. Low-cost flight opportunities are essential for the development of new instrumentation and for the training of graduate students. Special care must be taken to protect the funding of the suborbital program, balloons, rockets and aircraft.

We note that the fiscal year 1986 revised operating plan reveals that modifications planned for the Galileo II replacement aircraft will be deferred and planned sounding rocket activities will be reduced at a time when major flight programs are not available to the science community. We think these planned reductions are unfortunate.

In addition, NASA should provide support for both U.S. participation in flights of opportunity, both domestic and foreign. The training of the next generation of space scientists cannot wait while the shuttle problems are being rectified. The cost of continuing analysis of data from ongoing missions is a particularly cost effective means to advance science. Indeed, in this time of no flight opportunities, it is another means to provide educational opportunity for graduate students, and to put university research capabilities to productive use. Proposed funding for mission operations and data analysis in some cases has been significantly increased to accommodate missions that were to have been launched this year but are now delayed. Whenever possible, these funds should be directed to support university research.

The Nation's grief over the loss of the *Challenger* crew was accompanied by an overwhelming resolve to continue and move forward with the space program. There will be a shuttle program and eventually a space station. Similarly, there will be a vigorous space science program.

The President's proposed fiscal year 1987 budget contains a new start for the ocean topography experiment, TOPEX, and funding for instruments to be flown as part of the International Solar Terrestrial Program. We are particularly pleased to see these in the budget, as there were no new starts proposed in fiscal year 1986. These missions will provide for the orderly advance of U.S. space science, and are essential to the continuity of the program. Nothing should be allowed to interfere with their successful execution.

These are not only times of shuttle problems, but also of potential massive budgetary reductions. In the current fiscal year, the

Gramm-Rudman-Hollings reduction to the Office of Space Science is 4.6 percent, or $72 million. Coming, as it does, in the second half of the fiscal year, this reduction will result in unanticipated cancellations of grants, and will cause serious damage to the orderly execution of university research.

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We were dismayed to note that NASA's fiscal year 1986 revised operating plan reveals that the OSSA research and analysis budgets have been reduced in amounts in the range of 4.8 to 5.4 percent. According to the NASA document, these reductions do not involve the impact of the *Challenger* accident. We think it is unfortunate that these accounts, which have been funded at modest levels for the past several years, must bear a disproportionate amount of the legislatively mandated across the board 4.3 percent reduction.

The potential of mandated across the board cuts in fiscal year 1987 is estimated at approximately 8 to 10 percent below the post-Gramm-Rudman-Hollings levels for 1986. If a reduction of this magnitude is inflicted on the Office of Space Science and Applications, the Nation may cease to have a viable space science program. It is ironic and sad that an outcome of the Congress' near-term actions to repair the Nation's economy by cutting budgets is disabling the scientific infrastructure that is so crucial to the Nation's long-term economic health.

Surely there must be a better way to reduce the Federal deficit, and we encourage the Congress and the President to find it.

The development of the NASA budget this year has unparalleled significance. The recent stunning successes of the European, Japanese, and Soviet probes which photographed the Comet Halley and explored its surroundings provide a keen reminder of the high priority given to space research by the major industrial nations. The success of these probes and the conspicuous lack of a leading American participation in this adventure were outcomes of decisions made years ago. Similarly, the decisions made this year and next will determine the shape of the U.S. Space Program in the 1990's and will determine whether or not we maintain our leadership in space.

The budget must be designed to protect the essential elements of the Space Science Program against the consequences of reprogramming and budgetary reductions. It must protect the university space science community so it can continue to provide the underpinning for space science research in the future. It must advance space science with a new start for the TOPEX and with support of the international solar terrestrial program.

Let us not compound the shuttle tragedy by allowing irreparable harm to be done to the Nation's space science effort.

Thank you.

[The attachment referred to and questions and answers follow:]

NOTE: This analysis was completed on February 11, 1986 and is based on information available on that date. It may not address fully the impact of FY 1986 Gramm-Rudman reductions or programmatic and budgetary changes resulting from the Shuttle tragedy. The reader is referred to a separate statement by the Space Science Working Group on the Shuttle tragedy.

APPENDIX: ANALYSIS OF PROPOSED FY 1987 NASA SPACE SCIENCE BUDGET AND COMMENTS ON EFFECTS OF THE GRAMM-RUDMAN REDUCTIONS IN FY 1986

INTRODUCTION AND OVERVIEW

Following is an analysis of the FY 1987 NASA space science budget as submitted to the Congress in the President's budget message. This budget was prepared prior to the Challenger tragedy. At this writing, the full budgetary impact of that tragedy is unknown, so in this paper, the Space Science Working Group analyzes the FY 1987 budget as it was originally proposed. In addition, we have commented on effects of the Gramm-Rudman-Hollings budget cuts in FY 1986, although the full impact of these cuts is not known at this writing.

The proposed FY 1987 budget for the Office of Space Science and Applications preserves about the same level of activity in space science as there was in FY 1985. (See the budget table on pages A-7 and A-8.) The budget includes one major new start, the Ocean Topography Experiment (TOPEX) and instrument developmnet for the International Solar Terrestrial Program (ISTP). It preserves most other science programs that were underway, with the exception of the Solar Optical Telescope (SOT) which is proposed for cancellation. In general, Research and Analysis (R&A) budgets are approximately even with current levels.

It should be noted that this lean budget provides no flexibility to prepare for the types and levels of activities anticipated in the space station era. The development of research programs and scientific instruments to fly on space station will be needed in the near future in order to utilize the station's capabilities for space science.

If, as a result of the provisions of the Gramm-Rudman bill or other deficit reduction plan, there are major budgetary cutbacks in FY 1987, the nation's space science programs will suffer a severe and long-term setback.

PHYSICS & ASTRONOMY

The overall budget for Physics & Astronomy in FY 1987 is $539.4M, down by 11% compared with the initial FY 1986 operating plan and by 20% compared with FY 1985. This decrease is largely due to the fact that the two major flight programs in this division, the Hubble Space Telescope (HST) and the Gamma Ray Observatory (GRO), are well past the peaks of their funding curves, and Physics and Astronomy has seen no New Start authorization for a major flight program since GRO was approved in the FY 1981 budget.

Not only has Physics and Astronomy seen no new start in several years, but the FY 1987 budget proposes termination of funding for the Solar Optical Telescope (SOT), which, in previous years, had been an approved project as part of the Shuttle/Spacelab Payload line. This high-resolution optical telescope had been planned as the cornerstone of future studies of the Sun. It was expected to provide information concerning processes on the surface of the Sun which occur on size scales smaller than currently resolvable, and are thought to be vital to understanding the Sun and its terrestrial effects. Some way will have to be found to meet the scientific objectives of SOT.

The Shuttle Payload line does include funds for the Shuttle High Energy Astrophysics Lab (which had been planned for flight in early FY 1987), the Space Plasma Physics Lab (planned for the early 1990's) and several other missions.

The Explorer line, at $56.7M, shows an increase since FY 1985 which is approximately equal to inflation. This level will permit planned progress on the Cosmic Background Explorer (COBE); the U.S. experiments on the German X-ray astronomy satellite, ROSAT; the Heavy Nuclei Collector, a low-cost detector for ultraheavy cosmic rays scheduled for a reflight of the Long Duration Exposure Facility; development of the Extreme Ultraviolet Explorer (EUVE); and the Combined Release Radiation Effects Satellite (CRRES) and the San Marco-D joint mission with Italy to study the relationship between solar activity and meteorology.

The Mission Operations and Data Analysis (MO&DA) line shows a sharp increase in FY 1987 to $172.7M, up by $54.7M from the FY 1986 plan. This increase principally reflects the planned transfer of Hubble Space Telescope (HST) from the development to the operations phase. (The HST development line falls by $100M from FY 1986 to FY 1987.) HST efforts in the MO&DA line include actual telescope operations and data analysis as well as preparation for maintenance and refurbishment.

The Research and Analysis (R&A) line shows an 8% increase from FY 1985 to FY 1986 but is essentially unchanged in FY 1987 (a loss to inflation of several percent). The increase in FY 1986 was principally a reprograming of funds from other areas to begin the development of a Shuttle-borne engineering test of instrumentation for Gravity Probe-B (GP-B), which would later be developed as a free-flying satellite to test a fundamental hypothesis of the theory of General Relativity. This budget line also includes funding for Advanced Technology Development of the Advanced X-ray Astronomy Facility (AXAF) and the Space Infrared Telescope Facility (SIRTF). There is no effective increase from FY 1985 to FY 1987 in R&A funds for Supporting Research and Technology, the basic grant support for university-based space science groups.

The Suborbital Program shows approximately inflationary increases only from FY 1985 to FY 1987. This program supports sounding rockets, airborne science, and stratospheric balloons. In addition, $5.9M of this $64.4M line is scheduled for support of low-cost Shuttle payloads (Spartans) which replace some sounding rockets. One Spartan experiment and much of the common hardware which was planned to be used for future Spartans were destroyed in the Challenger accident.

NASA management in the division of astrophysics is considering the options for the Gramm-Rudman cuts, so the actual effects are not yet known. It appears that the cuts will not be apportioned uniformly across the division. For example, in Mission Operations and Data Analysis, some costs cannot be cut without severely impairing operations of existing satellites, or cannot be cut because they are already spent (e.g., SMM repair). As a result, other parts of that budget such as the grants to scientists who are analyzing data, are expected to bear more than the "standard" 4.8% cuts. Similarly, within the Research and Analysis line, it may prove necessary, to cut by substantially more than 4.8%, the budget used to fund Supporting Research and Technology, the principal source of basic research funds for university groups. It appears that some of the reserves in this division's original FY 1986 budget were used up when, as part of the FY 1986 operating plan $8M were transferred into R&A for GP-B. This makes the Gramm-Rudman cuts in FY 1986 particularly difficult to absorb.

LIFE SCIENCES

The Life Sciences Program is the key to developing a capability to sustain a pertinent manned presence in space and to utilize the space environment to study living systems. The requested budget for FY 1987 represents a modest continuation of the steady rise in funding experienced over the last three years. This request represents a 7% increase over FY 1986 which in turn was a 12% increase over FY 1985. The budget estimate represents less than 1% of the agency budget and approximately 5% of the OSSA budget.

The program is divided into flight experiments and Research and Analysis (R&A). The range of experimental interests in the program includes: 1) space medicine, 2) advanced life support systems, 3) gravitational biology, 4) exobiology, and 5) biospheric research. The flight experiments portion (49%), has grown 25% and 6% over the last two fiscal years. This growth reflects the active and expanding participation of the life sciences in shuttle and international flight activities. This budget supports dedicated spacelab life science flights (e.g., SLS-1, SLS-2, SLS-3), fractions of spacelab missions (e.g., SL-1, SL-3, EOM) and a program with smaller mission of opportunity experiments that can be flown in the orbiter middeck. Finally, life sciences is involved in several international efforts, including two recent Soviet Cosmos Biosatellite flights (D-1, SPACELAB-J, IML-1).

The Research and Analysis portion accounts for 51% of the budget which has grown at rates of 2% and 6% respectively from FY 1985 and FY 1986. This program funds ground-based and pre-flight research in basic biology and in those medical problem areas that affect manned spaceflight.

Currently, it is expected that the FY 1986 Gramm-Rudman reductions will be distributed evenly between the flight and research components of life sciences. At present, it appears that the combined influences of Gramm-Rudman, the earlier Congressionally mandated budget cut of $4M and flight hardware repairs, will constitute an approximate ten-plus percent reduction in the FY 1986 budget alone.

PLANETARY EXPLORATION

The FY 1987 budget proposal for the Planetary Exploration Program is a "level of effort" budget involving no new starts. It provides for the orderly continuation of the Galileo, Magellan, Ulysses, and Mars Observer missions. The Galileo and Ulysses development line items have been eliminated, reflecting the planned completion of the development phases of these missions. The Magellan (previously known as the Venus Radar Mapper) development line item decreases from $109.3M to $66.7M, reflecting the stage of development of the spacecraft. The Mars Observer (MGCO) budget increases from $37.8M to $62.9M, reflecting increased activity in spacecraft development, experiment development, and ground operations.

The Mission Operations and Data Analysis (MO&DA) line increases from $83M to $130.2M principally reflecting the progression of Galileo and Ulysses from development through launch to initial operations. The Research and Analysis line provides for the analysis of data from ongoing missions and for theoretical, laboratory, and observational studies in support of planetary exploration. The R&A line of $63.5M is 1% above the FY

1986 current estimate and, hence, constitutes a modest decline in terms of real purchasing power.

As a result of Gramm-Rudman cuts, the FY 1986 Planetary Exploration program will be reduced by $13M-$14M resulting in an approximate 5% reduction in available Research and Analysis support this year. The loss of the Challenger has serious consequences for this program because that shuttle was one of only two modified to accept the Centaur upper stage and, hence, capable of launching missions such as Galileo. It seems impossible to launch Galileo and Ulysses in the same launch window unless another shuttle is modified to accept the upper stage.

SOLID EARTH OBSERVATIONS

The proposed Solid Earth Observations Program budget for FY 1987 is at a level ($74.1M) about 1% less than in FY 1986 ($74.9M). The R&A lines in Geodynamics and Land Processes are either level with last year or show very modest increases.

The Crustal Dynamics Project, planned to measure the movement and deformation of the Earth's tectonic plates as well as variations in the rigid-body rotation of the Earth, is budgeted at $18.1M which is down 2% from last year and is about even with the 1985 level. With this reduction, there will likely be fewer baseline measurements made than in the current year and the pace and scope of the program will be correspondingly reduced. The parallel budget line for laser network operations is about at the FY 1986 level.

Several Shuttle experiments are planned, including reflights of the Shuttle Imaging Radar (SIR-B), the Large Format Camera and the first flight of a new multi-polarization, dual frequency radar imaging system (SIR-C). Technology development will continue for advanced spectrometer instruments for airborne and spaceborne use, including the Shuttle Imaging Spectrometer Experiment (SISEX). The FY 1987 budget line for these activities, at $21.6M, is down 6.5% from FY 1986.

ENVIRONMENTAL OBSERVATIONS

The proposed version of the NASA budget brings good news in the form of a "new start" for the Ocean Topography Experiment (TOPEX) mission. We are pleased to see the proposed allocation of funds for the development and construction of instruments for the International Solar Terrestrial Program (ISTP). Funding for the Upper Atmosphere Research Satellite (UARS) has been cut by roughly $10M both in 1986 and 1987. Thus, although a successful mission is still expected, funds for contingency and flexibility purposes have been lost.

Proposed Research and Analysis budgets do not keep up with inflation in this division as in others. However, this leaves the research program in a lean and inflexible status. Although decreases in Mission Operations & Data Analysis were expected in 1988 and beyond, the proposed decreases for FY 1987 would come sooner than expected. Funding for extended mission operations show a 10% decrease from present year funding. Continued data analysis of ongoing missions, particularly the highly successful International Sun-Earth Explorer (ISEE) and Dynamics Explorer (DE), remain an extremely cost-effective way to do science.

SPACE SCIENCE IN THE FY 1987 NASA BUDGET
(in millions of dollars)

	1982	a/ 1983	1984	1985	b/ Pre-GRH Cuts 1986	Proposed 1987
Total NASA	6020.0	6836.4	7217.5	7510.7	7587.2	7641.3
Total Research & Development	4772.0	1902.5	2028.5	2422.6	2756.8	3003.1
Space Flight, Control and Data Communications	-	3633.0	3775.3	3601.8	3397.9	3069.0
Total Space Science & Applications	896.2	1034.1	1157.0	1404.5	1548.5*	1464.0
Space Station	-	-	(21.9)	150.0	210.0	410.0
Total Physics & Astronomy	322.4	470.3	567.6	677.2	607.1	539.4
Space Telescope Development	121.5	182.5	195.6	195.0	127.8	27.9
Gamma Ray Observatory	8.0	34.5	85.9	117.2	87.3	51.5
Shuttle/Spacelab	47.6	81.0	80.9	105.4	108.3	115.1
Explorer Development	33.3	34.3	48.7	51.9	50.7	56.7
Mission Operations & Data Analysis	45.3	61.4	68.1	109.1	118.0	172.7
Research & Analysis	22.9	28.5	35.8	39.9	51.5	51.1
Suborbital	43.8	48.1	52.3	58.7	63.5	64.4
Total Planetary Exploration	210.0	186.4	217.4	290.9	352.8	323.3
Galileo	115.7	91.6	79.5	56.1	54.2	-
Venus Radar Mapper	-	-	29.0	92.5	109.3	66.7
International Solar Polar	5.0	6.0	6.0	9.0	5.6	-
Mars Geoscience/ Climatology Orbiter	-	-	-	13.0	37.8	62.9
Mission Operations & Data Analysis	42.6	38.5	43.4	58.8	83.0	130.2
Research & Analysis	46.7	50.3	59.5	61.5	62.9	63.5
Total Life Sciences	39.5	55.7	58.0	62.3	69.9	74.7
Flight Experiments	14.0	24.0	23.0	27.1	34.0	36.7
Research & Analysis	25.5	31.7	35.0	35.2	35.9	38.0
Total Solid Earth Observations	149.4	128.9	76.4	57.6	74.9	74.1
Laser Network Opns	81.9	58.4	16.8	8.0	8.5	8.6
Shuttle/Spacelab	12.3	14.5	17.0	12.1	23.1	21.6
Geodynamics	22.9	28.1	28.0	29.9	23.2	23.5
Research & Analysis	15.5	11.8	14.6	15.6	20.1	20.4
Total Environmental Observations	133.0	156.9	162.0	212.7	289.8	367.9
Total Research & Analysis	71.8	86.4	90.8	95.6	101.7	115.1
Upper Atmosphere	20.5	27.7	28.4	31.0	33.0	33.4
Atmosphere dynamics and Radiation R&A	22.3	26.5	27.4	28.5	30.3	30.9
Ocean processes	16.9	17.0	18.2	19.4	20.6	20.8
Space Physics	12.1	15.2	16.8	16.7	17.8	18.0
Shuttle/Spacelab	4.1	3.7	7.6	7.8	5.6	12.0
Earth radiation budget	24.0	24.0	15.5	8.1	2.0	-
Extended mission ops	16.1	22.8	27.4	29.5	37.0	33.6
Interdisciplinary R&A	-	-	-	1.0	1.0	1.1
Tethered Satellite Payloads	-	-	-	3.0	4.5	1.0
Scatterometer	-	-	-	12.0	14.0	35.9
Upper Atmos Research Satel.	6.0	14.0	20.0	55.7	124.0	152.2
Ocean Topograph Exper.	-	-	-	-	-	29.0

a/ Shown on a comparative basis with the budget structure changes instituted in FY 1984.

b/ The FY 1986 total budget figure does not reflect $322.7M in reductions mandated under the Gramm-Rudman law.

* The OSSA total figure does not reflect $75.0M in reductions mandated under the Gramm-Rudman law.

QUESTIONS OF SENATOR GORTON AND THE ANSWERS

NOTE: The following answers pertain only to the NASA science missions and programs of the Office of Space Science & Applications. They may not pertain to those programs considered to be exclusively applications.

Question 1. How will the suspension of Shuttle flights affect university space science and space applications research?

Answer. The suspension of Shuttle flights will immediately delay the launches of missions that were to benefit many university groups beginning this year: ULYSSES, Galileo, and the Space Telescope launches are the major examples. University groups participating in these missions had anticipated support from the flight programs, and this support is now delayed. The groups affected by the postponement of these major programs, and other groups affected by smaller postponed missions, need Research and Analysis funding to sustain their capabilities.

Depending on the length of the suspension of Shuttle flights, and the restoration of an orderly flight schedule, other university groups will be affected in coming years—for example, those groups participating in missions with anticipated launch dates in the next few years like the Gamma Ray Observatory mission.

Question 2. During this period when no Shuttles are being launched, how can NASA most effectively utilize its Space Science and Applications resources to prepare for the resumption of shuttle flights?

Answer. To keep the University groups strong and to provide training opportunities for graduate students and postdoctoral researchers, Research and Analysis funding becomes more important, and these budget lines should be protected. Continuing analysis of data from ongoing missions (such as ISEE, Voyager and Pioneer) provided through Mission Operations & Data Analysis budget lines will ensure new scientific results at a time when no new missions are being launched. Continuing this data analysis effort, and the related tracking activities, is a particularly cost-effective means of obtaining new scientific results and supporting some University groups. Unfortunately, in recent weeks, the developments in this area have not been encouraging: data analysis funds are being heavily cut. For example, in the case of data analysis for the ISEE spacecraft, which involves many University groups, it has been announced that fiscal year 1987 levels will be 28 percent below the current level, and that in fiscal year 1988, there will be an additional 25-percent cut. Additionally, flight opportunities through the suborbital program should be exploited at this time when there is no other way to get into space.

Question 3. Would a three-orbiter fleet adequately serve our nation's space science and applications programs? If not, what would suffer?

Answer. A four-orbiter fleet was not sufficient to serve space science programs, and so a three-orbiter fleet would only be worse if we rely completely on the Shuttle for Space Science and Applications. In an environment with severely constricted flight opportunities, only the largest, "showcase" projects like Space Telescope would have sufficient priority to fly. Smaller missions, such as Explorer class missions, which are actively and effectively used by university groups probably—and unfortunately—would be considered of lesser priority for the Shuttle manifest.

Question 4. To what extent could the Space Science and Applications program utilize expendable launch vehicles for missions and payloads previously manifested aboard the Shuttle? Would an ELV launch alter in any way the scope or capabilities of these missions and payloads?

Answer. The tradeoff between ELVs and Shuttle launches for previously manifested payloads depends critically on whether or not the payloads were to be retrieved or launched out of the Shuttle. In the case of payloads to be launched, such as ULYSSES and Galileo, an ELV launch is feasible. For Spacelab, Get-Away-Special, LDEF and other payloads which depend on retrieval, an ELV launch is not a viable possibility.

Question 5. As a result of the Shuttle accident, do you think there are fundamental changes in NASA's Space Science and Applications operations that should be considered? For instance, should NASA consider making its spacecraft and payloads compatible with both the Shuttle and ELVs?

Answer. The fundamental change that is required is a return to a mix of launch capabilities so that we again have ready, relatively inexpensive access to space flight. The record is clear: the four-orbiter fleet cannot handle the load of defense, commercial and space science needs. The Shuttle must be reserved for those missions which require manned flight, and the rest should be flown on unmanned ELVs. There is no reason why the Shuttle should be used—putting human life and a tremendous capital investment at risk—to launch communications satellites such as the Challenger was doing. There is no reason why the Shuttle should be used for ULYSSES, Galileo or other such missions.

It would be a mistake for NASA to make spacecraft compatible with both the Shuttle and ELVs, however. Such a policy results in every mission receiving the worst of both worlds: it must live with the worst-case compromises of two launch systems. This would only drive up costs, and reduce payload capabilities. NASA should assign to ELVs all missions which can be flown on ELVs, and reserve the Shuttle for the cases where it is truly needed. We feel that the flight rate that will be achievable with a safely run Shuttle program will be substantially less than current projections, and will leave the orbiters quite busy handling manned flight needs.

Question 6. Is NASA's Space Station program adequately accommodating the potential space science and space applications uses of the space station? If not, what changes should NASA consider?

Answer. The basic missing element in the space science program, as far as University Space Science groups are concerned, is the lack of NASA support to define missions for the Space Station. The resources presently allocated for this activity are woefully short of the level required to do a careful job. Without studies of scientific projects for the space station done at this time, it will not be possible for the scientific community to define its needs sufficiently early to impact the design of the space station. What will emerge is a facility that will undoubtedly have deficiencies for scientific uses which might have been alleviated had they been spotted early enough. NASA should consider a substantial increase in its funding for science definition studies for the space station.

Question 7. How might the scope and emphasis of NASA's Space Science and Applications programs be altered to enhance space science and space applications uses of the space station?

Answer. The best scientific applications of the space station will emerge by taking full advantage of the unique features of the space station (e.g., large carrying weight, adequate power) with instruments of the highest quality. The development of these instruments will be a lengthy process, but it must begin now in order that the scientific community is prepared to use the station when it becomes available. Testing of prototype instruments by short Shuttle flights, or balloon flights, will be essential in the development effort. This activity requires strong Research and Analysis funding support, as well as support for the suborbital programs and access to test flights on the Shuttle.

Senator GORTON. We have now started another rollcall vote, I am sorry to inform you. I think perhaps this is the best time for us to go and respond to it and get back as quickly as we can.

[Brief recess.]

Senator GORE [presiding]. The subcommittee will come back to order. We are going to go ahead and have a few questions while the chairman is coming back. We will have a few questions before he gets back and then we will go to the final witness of the day.

It seems clear from your prepared statements—I have reviewed them; I did not get a chance to hear all of your oral presentations—that all is not well in the area of space science and applications. Of course, we all want more resources than are available for various parts of the budget.

But in your case, I am concerned that that is not the case. What can this committee do to improve the health and well-being of space science applications? I know that is a general question, but what programs should be given a priority status and what alternatives should we consider to get more bang for the buck?

And if you could each respond briefly, I would appreciate it.

Mr. TOWNSEND. I would say the most important thing is to preserve a balance between all aspects of NOAA's programs—excuse me, NASA's programs. I was thinking of not just the ones we've been talking about today here, but on the aeronautics side of the house and in their research programs as well.

I think it is important that we do not end up in a situation where this disaster drastically unbalances NASA's activities. I think the balance has been good. You could quarrel that it was deficient here or deficient there, but NASA tended to move forward on what I consider most of the important fronts, particularly when they saw a technological or a scientific opportunity.

What I fear is that there will be an attempt to get as much of the money—to get out of the current problems as they can—out of their ongoing budget. And this could lead to some dislocations that would not be seen for many years. As you certainly are aware, many of these space programs, and even the aeronautical ones now, have life cycles of 7 to 10 years.

So if you cut out the research end of things or the studies of advanced missions, if you do that now, you will not see anything for some little time, and then all of a sudden you realize your competence in that area is gone and it raises a who-shot-John kind of a thing and we will have another crisis.

So I guess my advice would be to watch the balance. And Tom raised the same issue in the balance of the launch vehicles. It was a mistake to put all our eggs in the shuttle basket.

I do not know whether it is possible to draw up an absolute priority list between applications and science and aeronautics and materials research and things of that nature. The scientific and applications engineering community will assist, will give you ideas within the field, but it is very difficult to do this.

And I am not sure that it is always worthwhile, because what is important may depend upon what opportunity presents itself, where are the likely discoveries. I agree as an individual that the space telescope is the most important program to me, because I started as a physicist. I think there is opportunity there. There are untold possibilities for discoveries, really of amazing nature, because nature is doing a lot of things out there we do not understand.

Anyway, I guess I would not spend too much time in trying to make an absolute priority list. I would just watch in general the balance across those programs and make sure that what goes on does not end up stopping all sounding rockets, stopping the end of mission data analysis in the university and college community, and all those things.

Mr. DONAHUE. Well, as I tried to indicate in the summary of my testimony, what I would urge upon you is that you resolve to turn the Space Program around and to either carry on the Space Program at a level that makes sense for a flagship program for our Nation or get out of it altogether and leave it to the Russians.

The style in which we carried out the Space Program in the seventies was no style at all. It was a recipe for disaster, a recipe for the physical disaster that actually happened and a recipe for disaster for the Space Science Program, Space Applications Program, because we did not have access to space, and without access to space you cannot do a space science program.

We have not been able to launch a major space science program for the past decade. The last missions that were launched were those that were launched in 1978 and 1979, where we sent the *Voy-*

ager off toward the outer solar system and we sent *Pioneer Venus* off to Venus.

Since that time, we have not launched anything on the scale of *Voyager*. That is no way to do a space program. And so, that is what my appeal is all about.

And assured access to space comes down to acquiring expendable launch vehicles, acquiring other means of getting into space than the space shuttle, and doing it just as fast as we can go about it. Now, I could get into other details about the Space Science Progran, about the need to preserve SR&T for the sake of the health of the university community. As long as you want to have university support for a space science program, then the SR&T is necessary, and so forth and so on.

But I think the major thing that we have to learn is that we should do the Space Program right or not do it at all.

Senator GORE. Other than that, it is OK?

Mr. DONAHUE. That is right. That is my message.

Mr. MASON. Well, I would like to emphasize one of the the key elements that has been missing has been a lack of volatility. Now, we have a double problem; namely, the *Challenger* reprogramming problems and Gramm-Rudman-Hollings.

For Example, in our research group at Maryland we would like to hire a couple of postdoctoral fellows right now and we are looking at models in the fall that tell us our budgets are going to be cut in some unknown way by 8 to 10 percent, and we do not have any way of bringing people in on university salaries and moving ahead. So we cannot even spend the money that we have effectively in terms of getting more bang for the buck.

There is waste that goes on because of the uncertainties in the program.

Now, the *Challenger* has made that issue even worse, but the Gramm-Rudman-Hollings Program certainly has added to it. This especially impacts these lifeblood programs, research analysis, mission operations, and data analysis, that have been mentioned here by several people.

To keep interest in the program once we have decided on new starts like TOPEX or ISTP, once that has gone up through the peer review process and up through OMB and then presented, and these programs, if the Congress approves them, we must stay with them and not cancel them, as was done with the *Solar Polar* spacecraft, or stretch things out unnecessarily. That is a real disincentive for people to stay in the field.

Finally, the whole business right now, without a mix of launch capabilities it looks like we are going to be locked cut of easy access to space for the foreseeable future. And I think that problem has been raised a number of times here, but that is something that, 10 years ago we knew how to launch communications satellites, we knew how to launch Explorer satellites. We very carefully dismantled that capability in the interim and have thrown away the technology or put it into cold storage.

There was nothing terribly expensive about it, and we would get a better buy for our dollars by reexamining these programs that were very successful in the past.

I might say that Mr. Donahue commented on the lack of new missions. There was one very important scientific mission launched in 1984, which was the AMPTE mission international program, an Explorer project that was also launched with a Delta.

Senator **Gore**. Thank you.

Senator **Riegle**. Mr. Chairman, I just had one question.

Senator **Gorton** [presiding]. Go ahead.

Senator **Riegle**. I know we have one more witness, who apparently has a plane to catch, so I will try to be brief. Dr. Donahue, as I have been going through your statement, we have been involved in a debate on the floor, as a matter of fact, on budget issues, which has kept me over there for a period of time.

We are faced now with the question of whether we build another shuttle and the cost involved in that and the time that it is going to take and so forth, as sort of part of the mechanical side of being able to do anything up there, to augment our ability to do things, whatever the payload mix.

Now, you mentioned in your statement your feeling of frustration about the termination of expendable launch vehicles, and that is another avenue that is open to us. I mean, as we are starting to put what money we have available to put out there, we could put more emphasis on expendable vehicles and go in that direction. And obviously, we may do some of that anyway.

But the cost of another shuttle is a pretty expensive proposition, and I am just wondering. You folks are sort of on the outside looking in, and that can be a helpful vantage point. But are you of the view that it is essential that we go ahead and build another shuttle right away? And if the tradeoff were to perhaps not do that, but really high-ball the effort in the area of expendable launch vehicles, would you maybe see that as a more fruitful augmentation of our capability in order to be able to do more things and have the mix and so forth?

Mr. **Donahue**. That question is addressed to me, Senator?

Senator **Riegle**. I would be interested—that was directed at you, but I would be interested in short opinions from the others.

Mr. **Donahue**. I probably have already telegraphed my punch here. I think in the long run, if we regard as a given that there will be a space station eventually, it would be better to move now toward the acquisition of a means of getting hardware into space at a lower cost per kilo than we can do it with the space shuttle, and to plan eventually to get back and forth from the ground to a space station with a more efficient vehicle than the space shuttle.

So I would tend to argue that, although the pain may be great in the short term, in the long range it would be better to plan to acquire expendables. And if that means foregoing the replacement orbiter, so be it.

Senator **Riegle**. Mr. Townsend.

Mr. **Townsend**. I have to disagree with Tom. I think, in the first place, if you wait until a TAV is available to service the space station, you are talking about the year 2000 to 2010. Even though people are talking very optimistically about a transatmospheric vehicle, there is a lot of engine technology that has to be researched and proved.

As you undoubtedly are aware, the proposition is to do research and produce a test vehicle, X series type, and our experience, at least my experience in the past, has been that it is some little time before something that is shown in X version prototype appears in a full-blown version.

So what will happen if you said we will wait, is that you are saying in effect that we should not do a space station until that same timeframe. I think Tom probably really means that.

But I do not think that is good. I think we would be backing away too far from our role of leadership in this area, which I think is important to national security—differentiating between military security. And I think that trying to take on even a modest space station in the 1990's with three shuttles is a very risky proposition. They will be, you know, 10 to 15 years old at that time. All you need is a wing ding, and I mean just ding a wing, and you are down for a period of time.

I think that is pushing it.

Senator **Riegle**. Could I just ask you this on that point? If three is too few, is four enough?

Mr. **Townsend**. No, not in my view. Another committee that I am on in the National Research Council did a study of shuttle launch rates, which I would commend to your study. We did it because of you, Senator, who asked us to do it in what we kind of playfully call the NASA "overruns" committee over there. But it's really called the committee on NASA program changes, and if Congress asks for a study they get it.

We gave you a study. We said that the 24 mission per year estimate on the part of NASA was far too optimistic. We said, as I remember, 18. And we also warned, because Gene Covert and I are good friends and talk a lot, that we had some problems with some brakes and engine spares and all sorts of things, and if somebody did not get to wrestling that problem pretty quickly that 18 might be optimistic.

We did not have—and we said in the report, I think—in the first place, we did not have a notion a disaster. But we made it very clear, our report was not to be read in light of what could be done if we had a catastrophe of some sort.

No, I do not think it is. I think if it were a free world, I would want five shuttles and a good sparing program. Of course, it is not a free world. But on the other hand, this is one program where the United States clearly shows its leadership all over the world. It is open, it is much more open that DOD can be about some of their things, which are very fascinating.

But you know, it means things when you are over in Europe and there is a space mission and you see it, and feel it even in Moscow. So that is how I feel.

I recognize that I am talking lots of billions there, but nevertheless this is a very important thing we are discussing here today.

Senator **Riegle**. I agree with you, it is a very important thing. Mr. Mason.

Mr. **Mason**. Yes. Well, I would say that the space science community was not the driver for the shuttle, nor the space station. So I will not speak to that aspect of it, although obviously the community will make use of these facilities as best we can.

But I think it is quite clear that four shuttles are not enough to meet the needs of the Nation, and Jack has said the same thing. Five will not do it.

Now, if you are conserving dollars, the only way you are going to get the launch capability is to go back with cheaper rockets, which we were doing in the seventies. I think it is perfectly plain. John Young testified a few weeks ago that the previous year, with nine shuttle flights, he thought they were pushing the limits. Now, who knows what the limits are? But it is pretty clear that a four-orbiter fleet does not work, and the fragility of it—as Jack says, you damage one system and the whole apparatus comes to a complete halt.

It just cries out for a mix of approaches and multiple vehicles, and tells us of the folly that we have had of building—this tiny fleet is really like the Libyan Navy, to call four orbiters a fleet.

To take this and put the entire space and defense issues into such a small operation——

Senator RIEGLE. So does that mean then that we build a fourth one or do we build two more?

Mr. MASON. Of course, it depends on what you want to accomplish. If you have a fixed budget of $2 billion or $3 billion and say, can you buy the fourth orbiter or buy a mixture of Deltas and Titans, it is clear that you will do better with the Deltas and Titans.

If you say, no, I have got to build the space station, it depends on what you take as given. But it is for sure that we cannot—and the Rogers Commission has made it perfectly clear how it just went straight off the cliff trying to meet the needs of this country with four orbiters.

Senator RIEGLE. Let me just say, I think the momentum right now is, from the point of view of what the President has said and others, is that there is almost a reflex that says we have got to replace the one we lost, period. So we start there, bang, build one.

And we have not had much serious discussion yet whether building one just does not put us back into the same inadequate position. Maybe we should have built more way back when, and so maybe if you're going to build one you build two, you are in a stronger position.

But if the tradeoff is in the direction of more expendable vehicles and you really start to put yourself in a posture where you go down different routes at the same time, then that is quite a different substantive decision. And if you have got a block of money to spend and you sort of diversify it in two directions, rather than just sort of power pack it in one direction, you really change your capability for the future.

And I am beginning to think that that may be something of the choice that we are facing here. I mean, we really have to put most of our eggs back in the shuttle basket to take us on through the turn of the century or we are going to have to sort of play that down some and go not just to the space plane or some new successor outer space vehicle, but to the expendable vehicles as the augmentation part of it.

And I am just wondering if you sort of come out that multiple routes road or if you are basically of the view that says you have got to sink most of your money back into the shuttle program.

Mr. **Mason**. The probelm with all the eggs in one basket is, we are discussing it this afternoon.

Senator **Riegle**. We have got a basket we cannot even use right now.

Mr. **Mason**. We cannot even use it. Obviously, there is a symbolic benefit for rebuilding the shuttle. You know, it is your knee-jerk reaction: Well, we will fix it up and continue. But I think the Rogers Commission has made clear, and the evidence is all around us, that the four-orbiter fleet was not going to do the job.

And John Young has been very eloquent in pointing out how they were walking on the edge of a cliff for the last couple of years. So the fact is that, if you build the fourth orbiter and you look at the probabilities, chances are we will soon be back to three orbiters again.

And I think the question is, how do you get the pressure off the system. Well, one way to get the pressure off is not to put a $3 billion orbiter and human lives on the line to launch communications satellites, which is what the *Challenger* was doing. There was no need to do that. And it is clear that we have not been successful with calculating the risks associated with these flight.

Senator **Riegle**. Mr. Donahue, you may want to make another comment.

Mr. **Donahue**. Actually, Mr. Mason has said it very well. I speak here for space science, and for me the choice is clear. And the choice from the point of view of space science has got to be a capability that includes an adequate number of expendables. So that is my response.

Mr. **Townsend**. Senator Riegle, I am not sure that you cannot have some of your cake and eat it too here. If you rejuvenated the ELV industry through Government support, aiding and abetting them, and steer the Comsat's and the proven commercial ventures onto ELV's, it will not cost you a fortune.

Now, it will cost you a fortune if you are going to buy Titan Centaurs or the Air Force version of the Titan shuttle, Centaur, the big Titan. But if you encourage some of the commercial ventures—do not charge them full overheads but only additional identifiable expenses in the near term you may develop an industry in the future.

Sure, give them some Government support. I like the word "support" better than I do "subsidy," but we have been subsidizing things in this country since it started, and for good purpose in many cases.

So I do not think it is as black and white as these two gentlemen think. I do believe you better build a shuttle, but I do not think that that says that you should not diversify. I think the all eggs in one basket was a very poor move, but I do not think it is going to cost you a lot of money. It is going to cost you money, but I do not think it will cost you a lot of money.

Mr. **Donahue**. But the system you are talking about, Jack, if I hear you right, is one that involves launching of relatively small, modest missions with expendables, but does not allow the use of vehicles like 34-D7's.

Mr. TOWNSEND. The Atlas Centaur has a lot of capability.

Senator RIEGLE. In the interest of time, let me stop. I know we have a witness that has a plane to catch.

Senator GORTON. We do, and I have one question, a set of questions, I wanted to ask of Mr. Townsend.

First, Mr. Townsend, you were critical, perhaps even alarmist, about Landsat, the serious difficulties we have in falling behind in that technology, and your comparison with SPOT. Give me an outline, at least, of where you think we should be going with respect to remote sensing technologies and exactly what effect SPOT is likely to have on commercial viability of Landsat?

Mr. TOWNSEND. Yes, I was alarmist. I still feel and my board—now I am speaking for the board—feels very concerned. In the first place, there is no advanced instrument development going on of any note. That program should be picked up. NOAA would like to pick it up, but does not have the money. NASA feels that, given all their other problems, it just is not that high priority.

I am very concerned that this administration made a deal with my arch-competitor, RCA, on their commercial Landsat and then backs out of it. I do not like that. As much as it hurts me, I think that is not the right thing to do. That was a very tough negotiation and we were in that competition.

It was thoroughly examined up here on the Hill, and for the administration to turn its back on that kind of an effort to me is just basically wrong.

I just have to say it. Now, to a certain extent, events have overtaken us. SPOT has flown, and it was successful, and the French may grab enough of that market to keep Eosat in deep trouble. My own Leasecraft Program was mentioned a while back, and although a lot of things happened and NASA is going to do a little study of why and what we learned, the most important thing was, the market failed to develop the way we anticipated, and that is all important in a commercial venture.

When the Comsat first flew the market was there. It was just a question of could you address that market economically. There was radio. There were cables. There were telephone wires. There was everything. That is not true in the Landsat case. The market is still forming. It is not aggregated, and there are a lot of problems of that sort. I do not think that program can survive without a lot of Government support and encouragement. I think it is a terrible mistake just to simply turn it over to the French and the Japanese.

Senator GORTON. Thank you. Each of the members does have other things he would like to ask. We do have one more witness who is in a hurry, so we will submit some more questions in writing. Thank you all very much.

We will ask Mr. Braley to come forward, and I believe Senator Gore would like to make a statement.

Senator GORE. Mr. Chairman, I just want to particularly commend the testimony of this witness to the subcommittee. I think we can learn a great deal from Dr. Braley about the advanced communications technology satellite program, which is very exciting.

I will not steal his thunder, but let me say there is a special relationship that has developed between Shelby County, TN, the city of Memphis, Christian Brothers College, and Federal Express, all located in Memphis. It is creative relationships like this one which will play a great role in the future for enhancing our Nation's ability to stay ahead in the race to keep our technological superiority.

I will elaborate on these remarks for the record, but Dr. Braley is the chief scientist for the Federal Express Corp., and I just wanted to give him a special welcome.

Senator Gorton. We are delighted you did so, and with that great introduction, it is all yours.

STATEMENT OF RICHARD C. BRALEY, SENIOR MANAGER/EARTH STATION DEVELOPMENT, FEDERAL EXPRESS CORP.

Mr. Braley. Mr. Chairman, members of the subcommittee, I am happy to be here on behalf of the Federal Express Corp., Shelby County, the city of Memphis, and Chistian Brothers College to testify on behalf of the ACTS Program. I feel that for the future of Federal Express from a communications point of view, and for the needs of the Memphis area, that the ACTS Program would be extremely valuable to us.

Federal Express, as I am sure you know, is a rapidly growing package delivery company. We have substantial communication requirements for our base business. We are also getting into the communications business through the introduction of our ZAP mail product. There are other major corporations in the Memphis area who are also using substantial satellite communications to support the growing telecommunications requirements.

In the Memphis area, the city of Memphis, Shelby County, and Christian Brothers College are jointly developing the necessary resources and skill centers to provide the technical expertise required in a city which is undergoing such major growth in the high technology area. Our interest in the ACTS Program stems from that rapid growth and the attendant needs.

I would first like to focus on the Federal Express part of the ACTS Program, and comment on the value of the program which is being developed. Federal Express is currently developing a very large satellite based network which will, as I indicated before, support our ZAP mail product. The network architecture has a very large number of small Earth stations. It requires a very large complex switching center, and it also has large satellite requirements.

There are major ACTS technologies which are being developed which will support our future plans, and those technologies are the large switching capability of the satellite, the multiple beam antenna, and the laser technology which is being introduced in the program. Our current system which is being implemented utilizes existing technology. The type of technology which is being developed for ACTS will impact the approach which we will use to implement our long-range plans. The development of that technology, as I am sure you know, is very costly and very high risk.

Contrary to what the administration thinks, I do not believe that the private sector is going to pick up the tab for the development of that technology. The foreign countries, namely, Japan, France, the other European countries also realize the value of the technology which is being developed, and they are vigorously pursuing that development.

If the technology is not developed in the United States to provide the necessary system components, there is potentially a major loss of revenue for the United States. Federal Express prefers that we be able to procure from U.S. manufacturers, and we feel that from that point of view it is important that the United States be the first to supply the advanced technology that we will require.

The city of Memphis is a major center for medical research in this country. It is becoming a major center for telecommunications. Our medical community is intent on developing the capability to communicate nationwide via satellite with other medical research centers in the country. ACTS provides the capability to exercise the technology that we will need to implement the systems that are required for the future.

Christian Brothers College in Memphis has been funded by Federal Express and Holiday Inn and a number of other local corporations who utilize satellite telecommunications to develop a center for telecommunications at the college, and I might add that there is substantial funding, on the order of $7 million.

The objective will be to provide the precious resource of highly skilled technical people that we need to support the growing telecommunications businesses in the Memphis area. Training of these people utilizing real world experiments would be an invaluable asset to our community. ACTS will provide the resource which is needed to keep the eyes of Memphis trained on the future for satellite telecommunications.

Last year Maj. Bill Morris requested that the major telecommunications interests in the Memphis area join together to support an experiment program to participate in the ACTS experiments. I was selected as the principal investigator to coordinate the activities and see to it that the experiment was well defined and fit into the ACTS Program.

Currently the city of Memphis and Shelby County have provided $300,000 to support the program. In the fiscally restrained environment that we have today, I think this is indeed a very clear demonstration of the value which we in the Memphis area see in the ACTS Program. And we would be very disappointed, Mr. Chairman, to see the ACTS Program not funded.

Thank you.

Senator GORTON. I will defer to Senator Gore so he can question his constituent.

Senator GORE. I appreciate your courtesy very much, Mr. Chairman. Let me briefly ask you about this project. This is a research program that will support a number of experiments. One of the experiments is critical to the design and creation of the next generation of communications satellite technology. Is that correct?

Mr. BRALEY. That is correct. In fact, there are two major technologies which could have a significant impact on the next generation of our system. One is the multibeam antenna technology. We are currently planning to build a major telehub in the Memphis area. The capital outlay for that telehub will be between $50 and $100 million.

As the system grows, we will have a requirement for a second telehub with a similar cost. We would like to locate that telehub in the continental United States. With the existing technology that we have on the satellites that are available to us, we will not be able to locate that telehub in this country, in the continental United States, and that creates numerous logistical problems and added cost problems for us.

Senator GORE. Now, just so the subcommittee is clear on this point, NASA has this program, which gets the country through a technological bottleneck that we have to pass through not only to make this commercial project feasible in the future, but to make a wide range of other projects possible as well. Correct?

Mr. BRALEY. Yes, that is correct.

Senator GORE. Now, the companies interested in this, in getting through this technological bottleneck and achieving the scientific breakthrough include RCA, Comsat, TRW, Motorola, and others, correct?

Mr. BRALEY. Yes, that is correct.

Senator GORE. But with the change in status of AT&T, there is really no entity or consortium of entities in the private sector capable of making the kind of large speculative commitment to basic research necessary to achieve this breakthrough. Is that correct?

Mr. BRALEY. Yes, I believe that is correct, Senator. As you know, the development of space qualified hardware is extremely costly, and Federal Express would choose to implement the system differently and probably in a less cost effective way if we did not have the technology available that would be developed by the multibeam antenna system. Furthermore, we are currently implementing our major telehub, which will do all the switching for us terrestrially. The switching capability that will be provided by ACTS provides a different direction for us to go in for the next generation of our satellites.

Senator GORE. In other words, it holds open the possibililty of putting the switching equipment in orbit?

Mr. BRALEY. That is correct.

Senator GORE. Now, someone in a rural area of the State of Washington, or even Tennessee, for example, might as a result find a dramatic decrease in rural telephone rates.

Mr. BRALEY. Well, it is certainly possible, Senator.

Senator GORE. Well, if you look at the high percentage of those costs that go into the low density switching equipment, and speculate on what the placement of switches in orbit would lead to, I do not think it is merely conjectural.

Mr. BRALEY. Let me interrupt, Senator. I think, you know, the reason that Federal Express has chosen to go with the implementation of our system with our own satellites is for the very reason that land lines are very expensive. And I think that certainly addresses the argument.

Senator GORE. Absolutely. The efficiencies are clear. If we can get this system down to where we have switching equipment in orbit, the implications are enormous. Secondly, there is a saturation of the geosynchronous resource, or we are approaching saturation in the Western Hemisphere, at least, and it is clear that we have to optimize the use of that resource by vastly increasing the capacity of the satellites which are on station, correct?

Mr. BRALEY. Yes, that is correct.

Senator GORE. Now, this technology holds open the promise of discrete, tightly focused pulsed beams that optimize the use of that resource, correct?

Mr. BRALEY. That is correct.

Senator GORE. All right. Now, we have seen in your testimony the nature of this joint venture, and I would also like to point out that my colleagues, Senator Hollings and Senator Lautenberg, have pointed out in letters to Members of the Senate the absurdity of cutting NASA's only applied research program, which everyone admits could be a long leap forward toward maintaining our superiority in communications.

You mentioned that the Japanese have a program in this area?

Mr. BRALEY. Yes, that is correct. The Japanese are developing a 20-30 gigahertz system. They are developing switching technology and the capability to form very high intensity beams from satellite antennas.

Senator GORE. Well, maybe we can afford to just cede leadership to the Japanese in this area. Is it a small industry, not likely to be significant?

Mr. BRALEY. It is certainly not a small industry, Senator. If our system is implemented the way we plan to in the next 5 to 6 years we could spend, Federal Express, in excess of $1 billion.

Senator GORE. Well, the time to wring hands over Japanese technological challenges is not after the fact.

Mr. BRALEY. That is correct.

Senator GORE. We should instead clearly anticipate the challenge. We know it is there. We have a program that has been devised by NASA that is lean and mean. It works. It is highly successful. Private businesses in the United States are poised and ready to make massive investments to ensure our leadership in this new area if the Government will play this critical, small but critical, leveraging role and allow this technology to go forward.

I think it is a pretty strong case, and I just hope that we will see the merit of it. I feel optimistic that we will.

You have got a plane to catch. The chairman has been most gracious and courteous, and I appreciate the time.

Mr. BRALEY. Thank you.

Senator GORTON. Thank you very much, Mr. Braley. Your testimony and answers were enlightening and informative.

Thank you all very much. We are adjourned.

[Whereupon, at 5:28 p.m., the subcommittee was adjourned, to reconvene upon the call of the Chair.]

NASA AUTHORIZATION

WEDNESDAY, APRIL 16, 1986

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE,
Washington, DC.

The subcommittee met, pursuant to notice, at 2:05 p.m., in room SR-253, Russell Senate Office Building, Hon. Slade Gorton (chairman of the subcommittee) presiding.

OPENING STATEMENT BY SENATOR GORTON

Senator GORTON. Welcome to this hearing of the Subcommittee on Science, Technology, and Space as it considers the current and future state of our Nation's space transportation system and the various options which could create an assured access to space for civil and military space programs.

The January 28 explosion of the space shuttle *Challenger* and the death of its seven-member crew dealt our space program its more serious setback in its quarter-century history. One event has demonstrated all too clearly that our space launch capability was operating on a dangerously precarious edge—a situation that few of us, if any, dared to admit.

Now we find ourselves searching for the answers that will help minimize the effect that this pause in our ability to enter space will have on our program. In recent weeks, various sectors of the Government and the aerospace industry have focused on the immediate problem of preparing various launch vehicle policy options. A widely shared consensus has emerged around the idea of a mixed fleet, a concept that has not yet been adequately defined. Regrettably, the debate has become bogged down in technical and budgetary issues, and each of us here today continues to wonder just how long this debate will last.

As this subcommittee considers the various launch options designed to reconstitute our space launch capability, we are also faced with a number of policy issues that have been raised in the current debate. Now we are asked the following questions: Should the shuttle be used to launch commercial communications satellites? Should NASA manage its own ELV capability, or should it rely on a commercial ELV industry? And what, if anything, should the Federal Government do to ensure the viability of a U.S. commercial ELV industry?

During the next few months the United States will have a unique opportunity to reshape its future in space and, in the longer term, to reassert its leadership in space. There should be no doubt in anyone's mind now that launch capability is the key to leadership in space. The *Challenger* tragedy has forced us to look at what kind of launch vehicle capability we really need.

Make no mistake about it either, the rest of the world is anxiously watching our response to this challenge. Our response will either allow other space-faring nations to close the gap in our respective capabilities, or it will clearly reaffirm our preeminence in space.

In whatever manner we reconstitute our space launch capability, however, I believe that we should not do so at the overwhelming expense of our other space endeavors. Balance among space programs must be maintained even during these uncertain times.

With these thoughts in mind, the subcommittee is privileged to have today a number of distinguished individuals from Government and industry to provide their respective insights to this discussion. We look forward to their comments and to the resolution of the difficult problems that confront us as we seek to reestablish our space launch capability and once again continue our search beyond the stars.

Senator Riegle.

OPENING STATEMENT BY SENATOR RIEGLE

Senator RIEGLE. Thank you, Mr. Chairman.

This is the second and, I think, perhaps the most important of our series of hearings that we have planned on the 1987 NASA authorization. The subject of our hearing today is the assured access to space and our national space transportation policy for the future.

It seems to me that we face many issues now regarding our space transportation system which are both near term, or as near term as we can be, back into the air and on into the distant future. Issues, some of which you have mentioned, such as the appropriate mix of expendable launch vehicles and orbiters, commercial launch operations and foreign competition, are just some of the critical matters that make up the complex of issues facing us.

In the longer range, we are going to have to soon address and make decisions on the schedule of the space station, the follow-on transportation system to the shuttle, and exactly what our objectives are for the commercial development of space, as well as the exploratory efforts to the outer planets and throughout the galaxy.

While we were facing all of these questions prior to the loss of the *Challenger*, the dramatic change in our circumstance by that tragedy and the interruption that we are now involved in, I think, has served to focus dramatically our attention and our efforts in a new way, in a very difficult way. So the disaster has added really one more dimension to the debate, particularly whether we must purchase a new orbiter immediately with delivery in perhaps 3 years or so. Should we commit to orbiters is a question that is in my mind. As is the question as to whether we should have built five in the beginning instead of four and now have three, and we are in an inadequate posture.

So do we solve that by going back to four? Should we think in terms of going back to the original five that many sought? That, of course, relates importantly to the question of the timeframe over which the shuttle is going to have to be the work horse of our space activities. The question of when the aerospace plane, if it is going to come on line, when that might come on line, obviously has an important bearing on that.

And, of course, the related question, and that is the degree to which we want to move in the direction of enhancing the expendable launch vehicle fleet.

I am very interested in determining what the shuttle needs of the Department of Defense will be once the shuttle is operational again, because, as is well know by all here, they have bumping rights. And it is likely that the delay in the Shuttle Program is causing a very large backload of the DOD flights. This being the case, I think we have to inquire about the effects of the DOD priorities on other payloads, both commercial and scientific.

In the same vein, the Vandenberg Air Force Base shuttle launch facility is nearing completion after the expenditure of nearly $3 billion. When, if ever, will it be used to launch shuttles, especially if the Air Force proceeds with a complementary ELV Program? I think that is a question out there to which we do not have clear answers now.

Mr. Chairman, I would say quite frankly that the Space Program and in a very real way our Nation in relationship to these questions is in a very difficult position at this time, I think far more so than is generally realized by the public, because we still are largely focused on the accidents, its causes, and things that need to be done in the future. But the implications for what the Space Program can and should look like for the future, I think, are very complex, very important to our strategic situation, and very expensive.

We made a decision some years ago to devote all cargoes to the orbiter, with the net effect that our ELV fleet has been depleted to a very dangerously low level. Foreign competition both in launch capacity and in commercial development in space is a factor, I think, in all of our considerations today and will continue to be a factor in all future decisions.

Space is now internationalized. The race is no longer between two nations. The entire world has awakened to the commercial possibilities which exist in space, and other nations now have a certain advantage due to our incapacity to operate at the present time and for some period of time. But after 20 years of dominance in space, with the United States leading the world in new technologies and new frontiers, we face the very real possibility of falling into a different order in that competition, along with nations like Europe, Japan and, very certainly of course, the Soviet Union.

Those nations have already made their decisions, that they are in space to stay, with or without the United States. And in some senses they are in a position to profit from our misfortune at the present time, not that that is their intent as such. But clearly the decisions that we make today to put ourselves back into the game have to be the correct ones.

So I would say that those decisions that we are going to make in the weeks and months ahead will really determine our ability to establish and maintain our leadership now and out into the next century, which I think is critical to do.

I would just make one other point, Mr. Chairman, to those that are gathered here today and it repeats what I said the other day in our first hearing, and that is, I think, there needs to be balance in the Space Program and that we cannot allow any single component of our space activity to dominate and overwhelm the other aspects of the work that we want to do.

I think the defense missions, the commercial missions, and the scientific and research missions all have to be accommodated, and there has to be a reasonable balance. I think if we find ourselves becoming lopsided to the point where one dominates and the others begin to die as a result or are permanently in a sense damaged and reduced in terms of our ability to maintain those areas as well, and particularly in the kind of world situation I see developing, I think that would be a mistake.

So I for one am looking for answers here in terms of a set of decisions as to launch capability in the future that will enable us to maintain a balanced program.

Thank you, Mr. Chairman.

Senator GORTON. Senator Hollings.

OPENING STATEMENT BY SENATOR HOLLINGS

Senator HOLLINGS. Thank you, Mr. Chairman.

Mr. Chairman, on January 28, 1986, the world stood still. The shuttle *Challenger* had exploded. And, out of respect for those who lost their lives and the U.S. Space Program, all was quiet, everywhere. The United States had suffered a great loss—seven dedicated astronauts—and the world now shared in our sorrow much as they had shared in the joys and triumphs of the U.S. Space Program.

Since that day, pad A and pad B at the Kennedy Space Center also have stood silent. And that silence is now cause for serious concern since it severely impacts our national defense and civilian space policies. At first, it appeared there was a great deal of resolve to get right back on the pad and launch again. However, that was before it became apparent the disaster was an avoidable accident, the result of human and technical error and bad policy decisions. In light of these revelations, the debate now has become clouded, and the budget consequences became more real with each passing week. This subcommittee is now faced with the task of making a difficult decision as to the future course of the U.S. space transportation policy, but it finds itself poorly informed as to what options exist and what are the policy and budgetary consequences of these different options.

Today, the Subcommittee on Science, Technology, and Space has assembled a most impressive list of witnesses, people who are intimately involved with the public and private sector policymaking apparatus and with the future of the Space Program. In the course of today's hearing, I expect to get the official status of where we are, where we are going, and perhaps as importantly, when. I hope to find out what options exist for the near, mid, and long term, what needs to be done today to make these policy options viable, and what options are currently on the table at SIG Space. I also hope to find out that a new realism is being incorporated into the national space transportation policy, a critical element that in hindsight seems to have been missing from past policies.

Mr. Chairman, for the last few weeks, the Halls of Congress have been filled with rumors about where the Senior Interagency Group on Space [SIG Space] was going or wasn't going in the formulation of space transportation policy and budgetary recommendations in light of the *Challenger* disaster. Unfortunately, the Hill is receiving little or no factual information concerning the various policy options that are on the table, being discussed, or already resolved by SIG Space. Since all our Government witnesses are intimately involved with SIG Space, I hope to learn more about this process today. I also want these witnesses and SIG Space to know that I do not intend to rubber stamp their final work product. This is one Senator who intends to closely review the policy and budgetary recommendations of SIG Space to ensure the formulation of a realistic policy, a policy that safeguards the national interests, and that ensures launch opportunities for civilian, commercial, and national security payloads.

Mr. Chairman, in conclusion, let me indicate that I am still an ardent supporter of this Nation's space policy. But I am very concerned that our resolve seems to be diminishing, the decisionmaking process seems incapable of making timely decisions, and NASA still does not have a full time Administrator.

On January 28, I shared the sorrow of the shuttle disaster. I also indicated that the most fitting tribute to these brave few was to fulfill their dreams, to keep reaching for the stars. I still maintain that opinion, and I look forward to hearing from our distinguished witnesses today and to discovering what we need to do to get this program back on track in the most efficient and safe manner. Our Space Program has been silent too long.

Senator GORTON. Senator Rockefeller.

Senator ROCKEFELLER. Mr. Chairman, I also have a statement.

Mr. Chairman, with today's hearing, this subcommittee will begin its consideration of issues which fundamentally affect the course of our Space Program. Recognizing that many of our decisions hinge on the outcome of the investigation into the *Challenger* explosion, I welcome the subcommittee's proceeding to examine—at least preliminarily—our policy choices.

The *Challenger* accident made us painfully aware that we have not yet developed a completely safe and dependable form of space transportation. But the loss of the shuttle also forces us to focus with much greater clarity on what the goals of our civilian space program should be. We have various options for developing our space transportation capability—replacing the orbiter, increasing reliance on unmanned rockets, moving ahead with research on advanced aircraft that could ultimately replace the shuttle. But these decisions on alternatives—or various combinations of these options—should be guided by a clear vision of what we hope to accomplish in space.

I'm convinced of the promise of space exploration—and excited about the potential it holds for path-breaking scientific and medical discoveries and commercial development in the future. I look forward to advances we could achieve if we commit resources to the Space Program wisely. To me, this in part suggests a thorough understanding of the activities for which human travel to space is essential—and a sorting out of functions which could be performed successfully by unmanned vehicles. We should be reserving people for work in space that rockets and computers cannot do without them.

We all recognize that, at present, budget constraints are serious. Our financial resources, obviously, aren't limitless. But I'm concerned that budgetary pressures could produce short-sighted decisions: that the need to save money today will cause us to abandon our leadership in space exploration for decades to come. As other countries—the Soviet Union, Western Europe, Japan—move ahead with their space programs, we will look back someday with profound regret if we lower our sights now.

I would urge, however, that we retain a realistic view of the shuttle system's capabilities. The launch schedule—once problems with the shuttle are corrected and flights are able to resume—must be a sensible one. The economic pressures on NASA to achieve a particular flight rate—before the system is technically ready—must stop. There simply cannot be another accident if we want our civilian space program to go forward—and fulfill the potential we know it has.

Senator Gorton. We would like to welcome Secretary Aldridge and Admiral Truly. Before we hear from you, Mr. Secretary, we congratulate you on your recent nomination, and promotion, which I must say are well deserved. You are welcome here and we will be happy to hear from you.

STATEMENTS OF HON. E.C. ALDRIDGE, JR., ACTING SECRETARY OF THE AIR FORCE; AND REAR ADM. RICHARD H. TRULY, ASSOCIATE ADMINISTRATOR OF SPACE FLIGHT, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Secretary Aldridge. Mr. Chairman, I will start off the proceedings today. I have a formal statement which I will submit for the record. What I would like to do today is to briefly summarize that statement by making essentially five points.

First, we in DOD strongly support the policy that we should return to a space launch posture that is stronger, more diversified, and more robust than existed before the *Challenger* accident. As you know, I have been advocating such a launch posture for the last 3 years.

Second, the impact of the *Challenger* loss and the fleet downtime that will result will have a serious impact on the DOD space missions. A downtime of only 1 year will result in 10 DOD payloads waiting on the launch pad.

Third, there is nothing we can do within the next 2 years to mitigate the effects of the downtime and the reduced flight rate. We must simply live with what launch capacity now exists. Without congressional approval of the expendable launch vehicle program last year, we would be 4 years away from recovery as opposed to 2.

Fourth, to mitigate the longer term impacts, we must act now in the fiscal year 1986 budget to expand our launch capacity in the next 2 to 3 years.

And, finally, we must expand our launch capacity in a balanced way. We would encourage NASA to procure a replacement orbiter to more confidently meet our national manned space flight requirements. And we would support expanding the use of expendable launch vehicles to meet DOD unmanned space flight requirements. The expanded ELV production should provide a strong base for the United States to develop a commercial ELV industry to further augment our space launch posture.

We are working on a joint recovery plan with NASA and the other Federal agencies that can be submitted to Congress in the very near future.

Mr. Chairman, just to give you a summary of where we stand today in our launch capacity, I would like to draw your attention to this little display, which is the type of launch vehicles that currently exist in the United States that can be used for the future.

Of course, the shuttle, and the DOD will continue to make the shuttle a major component of its launch capacity. Approval last year of the Titan 34D7, the CELV, is shown. It has a launch capacity that is equal in size and weight to that which is provided by the shuttle. We expect to fly that vehicle in a little over 2 years, by October 1988.

The next vehicle is the Titan 34D, which is flying today. We have seven of those vehicles left in our inventory. They will fly out in the 1988 timeframe. It has been the work horse up until now for the DOD missions.

The next missile down is the Atlas Centaur. We have three of these vehicles left, which are based upon the old Atlas with the Centaur upper stage.

The next vehicle down is the Titan II—I am sorry, the Titan 34B model. We have one of those left. It is based upon the core vehicle of the Titan with an Agena upper stage.

The next is an Atlas K version, which is a version that is being proposed by General Dynamics to meet our mid-class launch needs, and we are looking at that for the future as a new vehicle.

This vehicle is the Titan II, the one we are now refurbishing from the silos. We will have 56 of those vehicles available. Our plan right now is to convert 13 of them for space launch vehicles to launch small class payloads into polar orbit.

The next vehicle down is what we call the wheatfield Atlas—the Atlas E's and H's. We have about 11 of those left. They are launching very small payloads out of Vandenberg, and they will fly out probably in the 1989 timeframe.

The other vehicle is a Thor Delta, which has been used by NASA for some commercial satellites. I believe we have about three of those left and they will fly out in the very near future.

And the last vehicle is a very small one at the end, the Scout vehicle, which is used to launch some scientific payloads.

Mr. Chairman, we are looking across this entire spectrum of what we might be able to do in the future. Certainly the CELV program we have under contract to build 10 of those. We have the Titan II, to convert 13 of those. And, of course, the rest of the vehicles will essentially run out of the inventory in the next 2 to 3 years.

We are looking at what we might be able to do to reintroduce some competition in the ELV industry to be able to launch some of the medium-class DOD payloads and continue to remove some of the pressures on the shuttle for the future, but yet still approaching this problem, as Senator Riegle had said, in a balanced approach. We are not going to abandon the shuttle, and we are trying to offload some of the pressures on the shuttie for DOD payloads that have to fly but yet not completely abandon or put too much pressure on the shuttle for launching DOD payloads.

That is our approach for the future and, Mr. Chairman, I would like to turn it over now to Admiral Truly for his statement.

[The statement follows:]

STATEMENT OF HON. EDWARD C. ALDRIDGE, JR., ACTING SECRETARY OF THE AIR FORCE, DEPARTMENT OF THE AIR FORCE

Mr. Chairman and members of the committee: I appreciate the opportunity to appear before you, although I wish it were under happier circumstances. In fact, I wish that I were here trying to defend the need for ELVs to complement the existing four orbiter fleet—as I have done for the last 2 years.

Unfortunately, recent events have made the need for ELVs and the need for a mixed fleet of launch vehicles mandatory. This requirement no longer is one of an "insurance policy" as it once was claimed by many of its critics. The issue of whether or not we need ELVs now no longer exists. The issue is what is the most appropriate national space launch posture.

The *Challenger* accident highlighted the vulnerability of our reliance on a single space transportation system for all U.S. space access regardless of redundancy and high reliability. However, this accident should in no way question the value or success of the STS Program and the unique capability that it offers the Nation. The objective of our recovery strategy should be to learn from this tragic lesson and rebuild a stronger and more balanced national capability that is largely independent of failures in a given system. We must structure our space program so that both the national launch capability and Manned Spaceflight Program are strengthened and more focussed as a result of this experience.

As a result of the *Challenger* loss, the nation is now faced with:

An orbiter fleet down until an appropriate fix to the problem can be implemented—estimates of the down time run between 1 and 2 years;

A three orbiter fleet to fly an anticipated 24 flights per year. Only two of those orbiters, *Discovery* and *Atlantis*, are capable of flying the heavier DOD missions;

A growing backlog of shuttle missions—DOD as well as civilian—resulting from the down time and from only having a three orbiter fleet.

As a result of congressional approval of CELVs and Titan II space launch vehicles, our ELV industry is now capable of providing additional ELV launch capability in a little over 2 years. We also have the capability to build a replacement orbiter in 3 to 4 years.

NEAR-TERM IMPACTS

The seriousness of the impact to DOD of this tragedy to a great extent depends on the down time of the orbiter fleet and what actions we take now to recover our space launch capability.

If the STS is down a year or more, there are serious near- and mid-term impacts.

Ten DOD payloads will be delayed from launch during the next year;

There will be a backlog of 25 to 30 equivalent STS flights prior to obtaining increased launch capability in 1989;

There will be a heavy impact on NASA missions because many backloged DOD missions must take priority when the flights are reinstituted.

If the down time is 2 years, DOD will have serious problems with 21 high priority payloads waiting on the launch pad for a launch opportunity. During this 2 year period, over 35 shuttle flights would be cancelled, requiring those payloads to be reallocated to later shuttle missions, converted to fly ELVs, or just cancelled.

Unfortunately, there is no alternative to alleviate the DOD launch requirements during the next 2 years. We must simply live with the delays incurred.

As you can see, there is a great incentive to find the problem and fix it as expeditiously as possible, but it must be done correctly.

LONGER-TERM IMPACTS

Unless we take immediate corrective action to restore our launch capability the longer-term impacts could be much more severe.

There are two approaches we could take to launch future DOD payloads. In the first approach, by fully exercising DOD priority we might be able to live with a three orbiter fleet as a result of our bumping rights. This would minimize the cost to DOD for alternate launch means but would have a major impact on non-DOD missions. Or in the second approach, we could obviously attempt to minimize the impact to NASA by off-loading to the maximum extent DOD payloads to ELVs. This would significantly increase the cost to DOD. The obvious choice is to attempt a more balanced approach.

The balanced approach would maintain the DOD shuttle missions where it makes sense to do so, and off-loading some DOD shuttle payloads to ELVs where it also makes sense. The payloads removed would be ones which could be shifted to ELVs without excessive costs or delays.

This balanced approach is most attractive from a "national" perspective. Based on our preliminary assessment, we can remove some DOD payloads from the STS manifest in the future to help NASA maintain a viable civil, foreign, and commercial launch capacity and yet fully meet DOD launch demands. This off-load requires us to maintain the manufacturing capacity through the mid-1990s to:

Increase the number and launch rate for CELVs beyond our current plan of 10 vehicles launching at a rate of 2 per year;

Continue the Titan II Program beyond the 13 vehicles included in our current plan;

Continued the existing ELV programs; i.e. Titan 34D, Delta and/or Atlas.

The details of this plan are currently being worked jointly with NASA.

THE NEED FOR A REPLACEMENT ORBITER

DOD will still be heavily dependent on the shuttle and will require about 4-6 launches per year from the fleet.

DOD's view of the requirement for the procurement of a replacement vehicle must be based on the overall manifest requirements. However, even with additional ELVs, it is not clear that the current three orbiter fleet can meet the demands of both NASA and DOD. Further, the maximum flight rate of the three remaining orbiters may not satisfy national launch requirements.

SUMMARY

To summarize, Mr. Chairman:

The near-term impact on DOD is severe if the orbiter fleet is down for a year. There is no "recovery" option that will mitigate this impact within the next 2 years.

We must procure and launch additional ELVs beyond our current plans and procure a replacement orbiter if we are to confidently meet our future space launch needs.

We must take this action now to minimize the negative long-term impacts of the orbiter loss. It is our intent that our recovery plan be a joint DOD/NASA plan.

This concludes my remarks.

[The following information was subsequently received for the record:]

QUESTION OF SENATOR GORTON AND THE ANSWER OF SECRETARY ALDRIDGE

ELV PROGRAM

Question. How will an ELV that meets performance requirements for a National Security Payload also compete in the commercial market?

Answer. By the DOD procuring a medium class expendable launch vehicle at a rate of four per year, the basic production capability and industrial base are established. These boosters can also be adapted by the manufacturer to meet the needs of the commercial sector. A planned initial procurement of 12 vehicles for the government with possibilities of commercial spin-off provides an incentive for competitive pricing and an American answer to foreign alternatives.

Admiral TRULY. Thank you, Mr. Chairman.

I appreciate the opportunity to be here today and likewise, with your permission, I would like to submit my formal statement for the record and summarize it.

Senator GORTON. It will be included.

Admiral TRULY. Earlier this year this Nation suffered a major setback which has brought issues to the forefront which we are dealing with here very properly at this hearing today. In order to recover this Nation's launch capability, I feel very strongly that this approach must maintain a balance for the future. It must obviously deal with our fiscal difficulties, and I feel extremely strongly that we have an opportunity here for this Nation to emerge from this difficulty stronger in our space capability than we entered it.

In the few weeks that I have been in my job and returned to NASA, these major issues have not been the ones that I have been primarily concentrating on, and I realize that this hearing today does not deal with the accident, the 51–I loss of the *Challenger*. I have two jobs, and the first one is to be the chairman of the NASA task force in support of the Presidential Commission in the accident investigation. And since I feel that the first step in regaining our assured access to space is to conclude this investigation, I would like to give you a very brief summary of my views as to where we stand.

We are supporting the Presidential Commission, and I anticipate that they will be able to report to the President on their required date early in June. The accident investigation, in my view, is going well. We have isolated the failure to the solid rocket motor joint.

Along that line, I would like to correct my formal statement that was drafted a few days ago, which stated that we have not located a piece of the part of interest. In fact, Sunday afternoon we pulled it to the surface and I was down at Cape Kennedy yesterday. We have it there with some propellant still in it, so it is very limited. But we do have a segment of the case joint that does include the burn-through location, and both the task force and the Commission investigators and metallurgists will be paying very careful attention to that.

In short, on the investigation itself, I think it is extremely thorough. It is as tough-minded as we can make it. We intend to find out, to locate if possible, the cause or the most probable cause, but I can assure you that that is moving well and we will reduce the possible causes to those that are correctable.

The second part of the job is one which looks to the future, and looks to a strategy for returning to safe flight of the space shuttle. I have directed within our system to do a number of things to do this, including a total review of our project management and the process by which we commit to launch. We have formed a large redesign team for the solid rocket motor joint, both including NASA personnel from the Marshall Space Flight Center, other centers, and national experts external to NASA.

We are conducting a complete review of the other critical items in the shuttle system, reassessing the launch and launch abort phases of the flights. I have given direction on the conduct of the first flight in the first year for planning so that we can assure ourselves that we are returning in a safe and conservative manner. And, most importantly, we have started a major effort to determine what we believe to be a safe and sustainable shuttle flight rate, and those are in work.

In summary, on the subject of assured access to space for this Nation I believe that the things that we must do today, first is to determine the cause of this accident and to recover from it, and I believe that we are doing both of those. We must face these fiscal and policy issues that I am sure will be the subject of many proper questions here in this hearing today.

I feel, as Secretary Aldridge does, that our solution must include a balance of capability for the future in our launch systems, and finally that we must make every effort to emerge stronger in our national capability than when we entered this difficult time.

Thank you, sir.

[The statement follows:]

STATEMENT OF RICHARD H. TRULY, ASSOCIATE ADMINISTRATOR, OFFICE OF SPACE FLIGHT, NASA

Mr. Chairman and Distinguished Members of the Subcommittee:

It is my pleasure to accept your invitation to testify before this Subcommittee today. I am here today to discuss the impact of the Challenger accident on our space launch capability and how we might most effectively minimize this impact and reestablish NASA's space launch capability.

With the loss of Challenger, we have lost one quarter of our Shuttle fleet. For at least the next three and one-half years, we will be limited to a three-Orbiter fleet. Additionally, there will most probably be a slower buildup in flight rate than had been planned before the accident. There will certainly be a shortfall in the U.S. space launch capabilities in the near term. A three-Orbiter Shuttle fleet and the associated infrastructure is estimated to have a flight capability of 16 to 18 flights per year. If an Orbiter had to be removed from the flight schedule for an extended period of time, and the Nation could only utilize a two-Orbiter fleet, the maximum flight rate would not be greater than 10 to 12 flights per year. Even after the three-Orbiter Shuttle fleet resumes flights, there will be a significant flight capacity shortfall and a backlog of significant payloads to be flown, and lost flight opportunities.

Although a detailed and very specific assessment of all the impacts of the accident upon our programs will not be completed until May, we can specify the various impacts in general terms. These impacts include the loss of an Orbiter and associated onboard hardware, required system modifications, and accident investigations and recovery costs.

My primary goal for the Office of Space Flight is that we achieve a safe and sustainable Shuttle flight schedule. We have established a planning baseline of 12 months stand-down, with a contingency planning schedule which assumes an 18-month stand-down. NASA priorities for flight payloads include critical national security requirements; major science payloads such as the Hubble Space Telescope or payloads with specific launch windows, such as Galileo; other NASA/Government payloads; and commercial and foreign payloads. The actual downtime and flight rate buildup, however, will obviously depend upon the specific changes that result from the thorough review of the program that is currently under way and the recommendations of the Rogers Commission. Our return to operations will naturally be a careful one, but we intend to make full use of the Space Shuttle as our Nation's primary space launch capability.

The eight Space Shuttle missions in calendar year 1985 achieved numerous technological, scientific, and commercial milestones which will provide an extremely useful base of experience when we return to flight. These included the retrieval and repair of the Syncom IV-3 spacecraft, the EASE-ACCESS demonstration of space construction which will be invaluable in developing plans for the Space Station, the flight of two Spacelab missions including the first reimbursable Spacelab mission, the first two dedicated Department of Defense missions, and five commercial Shuttle satellite missions. Several major scientific experiments, such as the Continuous Flow Electrophoresis System (CFES) and Physical Vapor Transport of Organic Solids (PVTOS), were also carried out. These experiments promise new or previously unobtainable quantities of materials and pharmaceuticals for medical and scientific uses.

The Administration, through the interagency process, is considering a broad range of options for recovery from the accident including possibilities of replacing the Challenger and expanding the use of Expendable Launch Vehicles (ELV's). It is premature to comment on their recommendations at this time.

Although production capability for a replacement Orbiter varies depending upon the specific contractor, the normal build time on an Orbiter, based on OV-103/OV-104 experience, is about 5 years. As a result of the structural spares program, many of the long-lead items, such as the aft fuselage and crew module spares, are nearly complete and an additional Orbiter could be available for flight in three and one-half to four years, after we have the authority to proceed.

In addition to the Shuttle, the United States Government does have a number of expendable launch vehicles which have been or were being phased out as payloads were transitioned to the Shuttle. These vehicles, which include Delta, Scout, and Atlas Centaur, have limited capability but could be used to supplement the Shuttle in delivering payloads in the near future. To date, we have identified two Delta vehicles which were previously assigned that could be used for other payloads if the Delta's were then replaced in a timely manner. There are three partially assembled Delta vehicles which could be used for replacement and for an additional payload sometime in 1987 or 1988. With a production turn-on, a launch readiness for the first of eight Delta vehicles could be achieved in about 30 months, with a rate one every two months after that. Production of new Atlas Centaur vehicles is estimated to require 36 months and could proceed at a rate of 4 to 8 per year. This is approximately the same length of time it would take to acquire a replacement Orbiter.

The Commission's report to the President is due the first week in June. The STS 51-L Task Force at Kennedy Space Center, which is analyzing the accident, are to report to the Commission on April 18. This task force is managed on a day-to-day basis by my Vice-Chairman, Dr. J. R. Thompson and includes six teams including a development and production team, a prelaunch activity team, a mission planning and operations team, an accident analysis team, a salvage support team, and a photo and TV team.

We are critically reviewing and evaluating all aspects of the program including a formal reevaluation of the STS program Failure Modes and Effects Analysis (FMEA) and the Critical Items List (CIL) as well as a reassessment of program management structure. While these activities are our most important activity, it is equally important that the program move ahead with corrective actions in the areas where design changes are required.

Our primary emphasis continues on the right Solid Rocket Booster (SRB) aft field joint. Major tests are in process at Morton-Thiokol and at the Marshall Space Flight Center to better understand the joint characteristics in various conditions. We are also destacking the SRB at KSC to analyze the effects of stacking on joint stacks. Although salvage operations have recovered two pieces of the suspect joint, no failed portion has yet been located.

Mr. Chairman, the most important step in achieving assured access to space is to identify the problems which led to the Challenger accident, to design and implement fixes for these problems, to assure flight safety when we return to Shuttle flight activity, to expand upon the base of experience we have developed, and to have a diversity of options in U.S. access to space.

It is clear that we have a considerable amount of work to do before we can give you definitive answers about many of the questions you have. As we make progress in these tasks, we will make every effort to keep you well informed of both our progess and the issues to be resolved. We appreciate the assistance you have given us in the past and look foward to your continued support as we deal with these issues.

Mr. Chairman, this is the end of my prepared testimony. I appreciate this opportunity to appear before you today, and would be pleased to answer any questions you may have.

QUESTIONS OF SENATOR GORTON AND THE ANSWERS

QUESTION 1:

In response to my question of whether or not the Shuttle should continue to launch commercial communications satellites, you indicated that NASA had a "number of commitments" that it "cannot walk away from."

The Subcommittee would appreciate your providing, for the hearing record, a list of these commitments--both contractual and otherwise-- and the expected launch date for these respective payloads. The Subcommittee would also like to know the legal nature of these contracts, as well as to what extent any of these customers have obligated funds pursuant to these contracts.

ANSWER 1:

The nature of these commitments is that of a binding contract between NASA and the customer. There are two types: Launch service agreements and Letter agreements. Both of these instruments commit NASA to the performance of agreed upon services.

Appended is a list of all customers having a contractual relationship with NASA; however, the launch dates given were the ones in existence before the accident. Projected launch dates are not currently available.

There exist other commitments which NASA has entered into by accepting earnest money payments from customers. These commit NASA to negotiate in good faith with these customers for potential future launches.

The following customers have made earnest money payments:

STS CUSTOMER SERVICES
COMMERCIAL PAYLOADS
EARNEST MONEY RECEIVED, NOT UNDER CONTRACT

	PAYLOAD	CUSTOMER	PAYMENT AMOUNT
1.	TELSTAR 3-B	AT&T	$100,000
2. *	SBTS-1/2	BRAZIL	$100,000
3. *	L-SAT	BRITISH AEROSPACE	$99,955
4. *	UNISAT-1/2/3	BRITISH TELECOM INTERNAT'L	$100,000
5.	TELESAT-K/L/M/N/J	CANADA	$100,000
6. *	CBSC-1	CHINA BROADCAST SAT. CORP.	$100,000
7. *	CBSC-2	CHINA BROADCAST SAT. CORP.	$99,985
8. *	SATCOL-A/B	COLOMBIA	$100,000
9.	DEDICATED	COMMERCIAL CARGO SPACELINES	$100,000
10.	D2	DFVLR (SPACELAB) WEST GERMANY	$100,000
11.	FASSC-1/2/3	FORD AERO. SAT. SER	$100,000
12.	SPACENET-D	GTE SPACENET CORP	$100,000
13.	SAX	ITALY	$100,000
14.	ITALSAT	ITALY	$100,000

15. *	LUX/DBS-A/B	RADIO-TELE-LUXEMBOURG	$100,000
16.	ORION-A/B/C/D	ORION SATELLITE CORP.	$100,000
17.	USSB-A/B/C	US SATELLITE BROADCASTING CO	$100,000
18.	WESTAR 8 THRU 17	WESTERN UNION TELEGRAPH CO	$100,000
19.	WESTAR KU-A THRU F	WESTERN UNION TELEGRAPH CO	$100,000
		TOTAL	$1,899,940

NOTES:
CUSTOMERS TOTAL 16
PAYLOADS TOTAL 49

* PROGRAM TERMINATED/OR IN INACTIVE STATUS
LSA = LAUNCH SERVICES AGREEMENT

The Department of Justice was asked by the Chairman of the Commercial Space Working Group, Economic Policy Council, for its views on the consequences of the Governments termination of agreements between NASA and organizations to launch commercial and non-U.S. Government payloads on space shuttle flights. The Deputy Assistant Attorney General of the Civil Division, Department of Justice, responded that if the termination was directed by the President, the NASA termination of the agreements would not be considered a breach of contract. He reasoned that such a termination would be in accordance with NASA's authority under a contractual provision in the standard launch agreement to terminate the agreement for reasons beyond its control.

QUESTION 2:

The Memorandum of Understanding (MOU) between NASA and the Strategic Defense Initiative Office (SDIO) dated November 1985, addresses the use of Delta vehicles 180 and 181, and parts from Delta vehicles 182-192.

What is NASA's current position concerning the rights of Transpace Carriers, Inc., and NASA, to make use of the Delta space flight hardware and materials not required under the November 1985, MOU between NASA and the SDIO?

ANSWER 2:

A Memorandum of Agreement signed in November 1985 between NASA and the Strategic Defense Initiative Organization (SDIO) commits NASA hardware for Delta vehicles 182-184 and material inventory for vehicles 185-192 which may be required for two SDIO experiments. SDI has recently requested two additional launch vehicles.

The Government's rights to the flight hardware for vehicles 182-184 and spares for vehicles 185-192 are contained in Amendment No. 5 signed by TCI and NASA in December 1985. Briefly, that Amendment states "...'Delta vehicles 180 and 181 are needed for other Government missions and are no longer available for potential use by TCI.

" 'The second stage of Delta vehicle 182 including its engine are needed for other Government missions and is no longer available to TCI or subject to the provisions of the basic agreement.

" 'Items of space flight hardware procured for Delta vehicles 182, 183, 184 and spares procured for Delta vehicles 185-192 may be needed for other Government programs. Pending definitization of the Government program for which these items are needed they are unavailable to TCI. NASA will use its good offices to encourage early definitization of the Government program. Subsequent to the definitization of the Government program, space flight hardware and spares not identified as subject to any Government program shall be governed by the terms of the basic agreement.'"

The NASA/TCI preliminary agreement expired with the expiration of Amendment No. 6 on May 31, 1986. It is NASA's position that, with the expiration of Amendment No. 6, TCI has no rights to make use of the Delta hardware and materials. It is to be noted, however, that NASA has continued to discuss with TCI its potential involvement in future Delta commercial launch activities.

QUESTION 002a:

Does NASA believe it has the rights to use any of this hardware or materials for NASA launches? If so, what is NASA's rationale for this position?

ANSWER 002a:

NASA has the right to use all of this hardware and materials for NASA launches or to support another Government program. Even if the NASA/TCI Preliminary Agreement was in effect, the Preliminary Agreement provided that space flight hardware and spares were subject to use for the SDIO's flight experiments and use for other Government programs. Thus, Delta spares and hardware were to be made available for TCI's use only if no other Government program needed them. NASA plans to use an existing Delta vehicle (currently assigned to a DOD mission) to satisfy the launch requirement for an Indonesian satellite in early 1987. At this time, we further plan to complete three partially assembled vehicles to replace this Delta and to satisfy the urgent needs of two additional SDIO missions.

These actions do not signal a return of NASA to "business as usual" in operating a mixed fleet of launch systems for the U.S. commercial and foreign commercial market place. NASA has no intention to reenter the commercial launch field using expendables. The Administration, through the interagency process, is currently examining issues related to commercial ELV operations and U.S. space launch recovery strategies.

QUESTION 002b:

What is NASA doing to resolve the disposition of this hardware and materials? How will such efforts effect Transpace Carriers' efforts to privatize the Delta Program? When will NASA provide clear direction?

ANSWER 002b:

NASA has met with TCI, and TCI has committed to enter into a contractual arrangement with McDonnell Douglas to document a listing of long-lead materials which may be residual to the U.S. Government's needs. The SDIO has expressed urgent need for access to the material for additional requirements.

NASA believes that availability of long-lead materials could enhance TCI's efforts to privatize Delta, but NASA does not believe that such materials are essential for or a prerequisite to TCI effecting contracts with Delta vehicle contractors and suppliers for commercial Delta production.

NASA intends to provide to TCI confirmation on the availability of any materials residual to the U.S. Government program, after completion of the MDAC documentation of this material and agreement with SDIO, on SDIO's requirements. TCI has had direction for several years on terms and conditions applicable to TCI's use of any U.S. Government flight hardware and materials for commercial Delta production.

The Administration, through its interagency process, is currently examining issues related to commercial ELV operations and U.S. space launch recovery strategies.

QUESTION 002c:

Does NASA intend to re-enter the activity of launching Delta vehicles?

ANSWER 002c:

NASA currently plans to fulfill its commitments for the SDIO program and for the NOAA GOES program, through 1987. Due to the Challenger accident, the Administration has been reviewing strategies for U.S. space launch recovery, and NASA is currently planning to satisfy urgent needs of only one of the committed users of the shuttle, Indonesia, in addition to SDIO requirements. The NASA Administrator has assured other agencies and the Administration that NASA has no intention to re-enter the commercial launch field using expendable launch vehicles. Recent planning actions regarding the launch of an Indonesian satellite do not signal a return of NASA to "business as usual" in operating a mixed fleet of launch systems for the U.S. commercial and foreign commercial concerns. The Administration, through the interagency process, is currently examining issues related to commercial ELV operations and U.S. space launch recovery strategies.

QUESTION 002d:

What operational advantages are there to the United States Government taking over and operating the Delta program?

ANSWER 002d:

The Administration policy, established by Executive Order 12465 of February 24, 1984, clearly states that the U.S. government will encourage, facilitate and coordinate the development of commercial expendable launch vehicle operations by the U.S. private sector.

The Administration, through the interagency process, is currently examining issues related to commercial ELV operations and of U.S. space launch recovery strategies.

CUSTOMERS UNDER CONTRACT --Deployable Communications Satellites

				REIMBURSEMENT	
CUSTOMER	PAYLOAD	LSA/LA Launch Date	PRE 51-L Launch Date	$M Received	CONTRACT BASIS
Western Union	WESTAR VIS	6/86	6/86	4 8	LSA 1-10-84
Indonesia *	PALAPA B2P ★	8/86	6/86	12 8	LSA 10-17-84
UK Ministry of Defense *	SKYNET 4A ★	6/86	6/86	17 8	LSA 7-15-85
UK Ministry of Defense *	SKYNET 4B ★	12/86	1/87	18 4	LSA 7-15-85
India Dept of Space *	INSAT IC ★	6/86	9/86	12 7	LSA 12-17-84
India Dept of Space *	INSAT ID ★	10/88- 9/89	NM	--	Proposal Acceptance
GTE Spacenet	GSTAR III	10/86	11/86	9 3	LA 10-4-82
American Sat Co	ASC 2 ★	10/86	1/87	9 0	LSA 8-3-84
Satellite TV Corp	STC DBS 1	11/87	11/87	6 9	LA 5-3-83
Satellite TV Corp	STC DBS 2	2/88	7/88	3 8	LA 1-31-84
INMARSAT	INMARSAT II-1	7/88	7/88	1 7	LSA 12-16-85
INMARSAT	INMARSAT II-3	3/89 2/90	NM	--	LSA 12-16-85
Hughes Comm Ser Inc	SYNCOM IV 5 ★	9/86	11/86	--	LSA 8-9-85
Hughes Comm Inc	HC 9 ★	12/87	12/87	5 8	LSA 12-5-85
Hughes Comm Inc	HC 10 ★	11/88	NM	--	LSA 12-5-85
Hughes Comm Inc	HC 11 ★	5/88	6/88	--	LSA 12-5-85
Hughes Comm Inc	HC 12 ★	2/89 1/90	NM	--	LSA 12-5-85
Hughes Comm Inc	HC 13 ★	6/89 5/90	NM	--	LSA 12-5-85
Hughes Comm Inc	HC 14 ★	11/89- 10/90	NM	--	LSA 12-5-85
Hughes Comm Inc	HC 15	6/90 5/91	NM	--	LSA 12-5-85
Hughes Comm Inc	HC 16	11/90- 10/91	NM	--	LSA 12-5-85
Hughes Comm Inc	HC 17	6/91 5/92	NM	--	LSA 12-5-85
Hughes Comm Inc	HC 18	11/91- 10/92	NM	--	LSA 12-5-85
RCA Americom	RCA 4001 ★	3/89	NM	6 1	LA 12-27-84
RCA Americom	RCA 4004	3/89	NM	--	LA 8-10-84
RCA Americom	RCA 4005	9/89	NM	--	LA 11-29-83
RCA Americom	RCA 4006	6/91	NM	--	LA 10-3-83
RCA Americom	RCA 3001	6/90	NM	--	LA 8-7-84
Sat Transponder Leasing Corp	SBS 6	10/87- 9/88	11/87	4 7	LSA 6-21-85
INTELSAT	INTELSAT VI-3 ★	7/87	7/87	31 0	LSA 2-13-86
INTELSAT	INTELSAT VI-4 ★	2/88	2/88	21 4	LSA 2-13-86
INTELSAT	INTELSAT VI-5 ★	12/90- 11/91	NM	--	LSA 2-13-86
*Govt to Govt MOU exists	★ Payload Specialist				

CUSTOMERS UNDER CONTRACT

Germany (BMFT) *	Spacelab D-2* ★	9/88	NM	--	
Japan (NASDA) *	Spacelab J ★	2/88	2/88	18 3	LSA,3/30/85
ESA	EURECA L	3/88	3/88	3 1	LA,6/1/85
	EURECA R	9/88	NM	5	LA,12/1/85
	*Contract not final Payload Specialist ★				
INTEC/Merritt	HS376R-Palapa	By 12/31/87*	NM		LSA,11/2/84
Merritt	HS376R-Westar	(No Date Commited)	NM		LSA,10/22/84
GEOSTAR Corp	GEOSTAR-1	(No Date Commited)	NM		LSA,11/85
	GEOSTAR-2	(No Date Commited)	NM		LSA,11/85
	GEOSTAR-3	(No Date Commited)	NM		LSA,11/85
Space Industries, Inc	SII-1	(NO Date Commited)	NM		LSA,8/20/85
	SII-2	(No Date Commited)	NM		LSA,8/20/85
	SII-3	(No Date Commited)	NM		LSA,8/20/85
Canada	CANEX-2 ★	(No Date Commited)	3/87		Letter
	Payload Specialist ★	*Launch by this date at low price			

LSA (Launch Services Agreement)
LA (Letter of Agreement)

Senator GORTON. Admiral, nowhere, either in your written or your oral statement, was there an explicit call for a replacement orbiter. Has NASA made such a request? Is that its position before the senior interagency group? And did you say that we are now not to expect that group's recommendation until June?

Admiral TRULY. Let me answer the last part of the question first, sir. No, sir. I said that the Presidential Commission's report on the accident, their report to the President, is due in June.

As to a replacement orbiter, NASA has taken the view that the most economical way to regain our capability is for us to replace the *Challenger*. However, that is and has been under intense scrutiny within the interagency group. I must tell you that I have not been a part of that process. I have not attended any of the meetings. But NASA does support the replacement of the *Challenger* just as quickly as is possible.

We also support, however, the balance that is required, as Secretary Aldridge has testified, with a continued emphasis on the CELV program.

Senator GORTON. When are we to expect the senior interagency group's recommendation?

Secretary ALDRIDGE. Mr. Chairman, I think I can answer that. The Senior Interagency Group on Space will meet on Friday to address these issues. There have been a series of working group meetings and midlevel meetings on this particular topic over the past month or so, and we hope that maybe by Friday we will have had the issues raised to the point where it can be presented to the President for a decision on what the administration position is going to be on the approach to the recovery program, whether or not a replacement orbiter is included, the extent of ELV production, a technique for funding this particular problem, because the funds are significant to recover from this accident, as well as some other issues on the Government's approach to commercial satellite launching.

We believe that those issues will be discussed at that senior interagency group and hopefully we will get on with getting a decision by the President so we can present our plan to the Congress as quickly as we can.

Senator GORTON. Admiral, assuming that NASA gains approval for a replacement orbiter, will four be enough to serve NASA, or is that still too narrow a margin for error?

Admiral TRULY. That is an extremely difficult question, and I think my most truthful answer and personal opinion is that will have to be debated on the cost-effectiveness basis. I do believe that the space shuttle will have to continue to be the basis of our launch capability throughout the decade of the 1990's.

I think that one prudent approach to that, which is what we have recommended, would be that at the time that we go forward with a replacement orbiter that we also go forward with the replacement of our structural spares, which would allow the decision to be delayed somewhat on the fifth orbiter. The availability today of the structural spares that were approved a few years ago makes the availability to the Nation of a replacement orbiter about a year and a half sooner than it would be otherwise, and I think when we go forward that that would be the prudent thing to do at a minimum.

Senator GORTON. We hear a great deal about a concept called a mixed fleet, though it is a relatively flexible term so far. How could a mixed fleet of shuttles and ELV's serve NASA? What kind of combinations might you foresee and what kind of requirements does NASA have that a CELV would accommodate?

Admiral TRULY. I think the need for the mixed fleet is a national need, not a NASA need. The definition of it is the capability of launch access that does not depend on a single system for the heavy payloads the space shuttle and the CELV would provide. There are, I believe, heavy NASA missions that might very well in the future go on the CELV, if that made sense for the particular mission.

I think the logic to the need for a so-called mixed fleet is a national need, and I believe that it does make sense for us to go forward and continue to support the space transportation system, the shuttle, and ELV's, as we have discussed.

Senator GORTON. Secretary Aldridge, in your statement you indicated that in order to accommodate DOD offloading from the shuttle, DOD will increase its production of CELV's and its refurbishment of Titan II's and the conitinuation of some existing ELV programs. Can you be more specific? How many more CELV's and Titan II's do you think you will need beyond those which have already been approved, and to what extent will you continue with the existing ELV programs?

Secretary ALDRIDGE. First let me caveat by saying that the plan that we have submitted to the senior interagency group has not yet been approved by the Administration or the President, and so I am speaking from what we are using as planning figures at this particular point.

They are rough numbers. I cannot be more specific than to say it is our estimate that we have 10 CELV's approved by the Congress that would run through the 1992 timeframe. We are looking at options that would roughly double that, which would run at, rather than a two-per-year rate, could run at four or five per year of the CELV class. That would remove some of the heavier and launch-on-demand type payloads from the orbiter.

It would reduce some of the pressures on the orbiter to fly those particular DOD payloads. It is clear, however, we could not do that and begin offloading some of those payloads from the orbiter until the 1989 or 1990 timeframe, when this increased production rate would become available. We cannot accelerate that program any more than it has already been accelerated. We can accelerate the production rate once the first one is available.

We are looking at launching the smaller type payloads, the unique-type payloads, on Titan II's that would go beyond 1992. There is a classified payload and the defense meteorological satellite program which would fly on the Titan II. Rather than fly it at 2 per year until the 13 are used up, we would probably continue flying it at 2 per year through the mid-1990's.

There is another class of payloads that we are looking at that could possibly use what we would call a medium-class expendable launch vehicle. An example of a medium-class payload would be the GPS, not so much the launching of the initial constellation of the Navstar GPS, which the shuttle is currently manifested to fly, but to launch those off an ELV in a replacement mode, in other words, when we have a GPS failure.

Senator GORTON. You still intend to launch your first GPS on the shuttle?

Secretary ALDRIDGE. Yes, sir. There is nothing we can do to get that vehicle on anything other than the shuttle in the next 2 years, so we would plan to have the shuttle fly and deploy the initial constellation of GPS satellites. However, when we have an on-orbit failure—and we will have on-orbit failures with an average life of roughly 5 years—we will have those which we need to replace.

When it comes time to replace those vehicles, an ELV with a GPS capability on it would be ideal, where we would not have to go find a ride-sharing partner to avoid the GPS, which only takes about 20 to 30 percent of the payload bay, having to pay for the entire payload.

Senator GORTON. What type of ELV?

Secretary ALDRIDGE. That is what I was going to get to, sir. There are several of them which could possibly do that job. We could talk about a Titan 34B, the core vehicle of the Titan. We can talk about an upgrade of the Atlas, which would be an Atlas K. There are variants of the Thor Delta, and there are variants of the Titan II that could be used.

So our attempt there would be we would go under a competition for the GPS mid-class booster. But I would make a very strong point in that competition. That competition should have a vehicle that has a variant capable of launching commercial satellites.

We would make that a source selection criteria so that we could have a commercial satellite ELV competitor with Ariane for this country. I think that competition would provide that capability, and we could do so by the 1990 time frame.

Senator GORTON. Is that a policy with which NASA agrees?

Admiral TRULY. NASA supports the development—if that is your question—of the capability to develop a viable commercial ELV capability in the country, and we have.

Senator GORTON. Is NASA likely to reestablish and manage its own line of ELV's, or simply purchase them on a case-by-case basis?

Admiral TRULY. We have no plans to procure or manage the procurement of future ELV capabilities, as the Secretary mentioned, and where it was not appropriate to fly the satellite aboard shuttle we would gain our capability from the DOD or from, under certain conditions, a viable domestic industry.

Secretary ALDRIDGE. Mr. Chairman, we would not do any of these programs of ELV's in isolation. They would be done certainly jointly with NASA. Their requirements must be taken into account and in any ELV procurement that we would undertake the NASA requirement should be factored into that acquisition.

Senator GORTON. Is this just a matter of pure cooperation or would that have considerable economies of scale?

Secretary ALDRIDGE. Well, I think one is cooperation. I do not think there is any doubt that there is a strong degree of cooperation between NASA and the Air Force and the Department of Defense. But in terms of participation in the procurement, the thing which gives us the economies of scale is the number of vehicles we procure per year.

If we can get up to four or six per year of this class of ELV, then the cost per launch becomes very, very attractive for any user, and I think it would be to the benefit of the commerical satellite people, in fact any satellite builder, to get those rates up to something that is economical.

Senator GORTON. If the shuttle were precluded or prohibited from launching commercial communications satellites by congressional action or by policy, Admiral, do you think this would guarantee the viability of a U.S. commercial ELV industry?

Admiral TRULY. Again, I think that is a very difficult question. I do not think that in itself would guarantee it. Frankly, we have a number of commitments that I feel very strongly that the shuttle should not and cannot walk away from. But we do support the eventual use of a commercial satellite—I am sorry, a commercial or privately financed ELV industry in this Nation to launch commercial satellites.

Senator GORTON. You really have a chicken or egg problem here, though, do you not? Until they have a market, it is not going to develop, and yet, you do not know if the market will develop.

Admiral TRULY. That is true. In my view, the difficulty is the transition period because the company, the private company that is in the business of launching satellites must have a manufacturing capability. It must be able to meet demand. It must be able to develop pricing structures that make it competitive with Government-sponsored foreign communications satellite capabilities. It must be able to meet the launch rates required.

And that is why I say that, in your original question, that the mere exclusion on a particular early date from space shuttle use would not guarantee the development of this viable capability.

Senator GORTON. Secretary Aldridge, how many GPS satellites would be in that initial constellation?

Secretary ALDRIDGE. Roughly 20. I believe the number is 18, with some spares.

Senator GORTON. If we have only a three-orbiter fleet during the course of the next 3 or 4 years—and that seems pretty obvious—to what extent would you anticipate DOD exercising its preemptive rights to the shuttle? Would you use everything?

Secretary ALDRIDGE. No, sir. I think, depending on the down time—and I caveat all of this—if we are down for, like I said, 1 year, we will have 10 payloads that will be stacked up ready for launch. If we are down for 2 years, we will have 21. When it comes time to fly again there obviously is going to be great pressure to get those payloads off. They are not scientific. They are operational. They are used to replace on-orbit satellites. They are used to give us improved capabilities that we did not have before. So there will be great pressure to fly those particular vehicles as quickly as we can for replacements.

The way the process works, however, is that when we look at our needs we try to integrate and iterate those needs with NASA. We understand there are some pressures on NASA, such as Galileo and Ulysses for the planetary flights. We know the Hubble telescope has a lot of pressure on it. And we know the various spacelabs have political pressures.

We try to iron out and to compromise the launch manifesting with NASA. We spent last Friday beginning that process at Vandenberg, as a matter of fact. Dick Truly and I were both out there with NASA and Air Force people.

Senator GORTON. What do you realistically expect the flight rate to be in the first 2 or 3 years after the shuttle is back?

Secretary ALDRIDGE. Our presumption is that the flight rate should be something that is very conservative, at a fairly low rate. Exactly what that number is, I cannot answer. I am relying upon Admiral Truly, with the letter that he put out, to build up a flight rate which can be confidently and reliably maintained starting from the bottom up, and of course we will just have to live with their assessment of how we think that they will be able to fly.

Senator GORTON. What is that assessment, Admiral Truly?

Admiral TRULY. The groundwork to allow me to review it and recommend a rate is in the works, and we hope to have an initial assessment of that in early to mid May. For budgetary and planning purposes the rate that we have baselined is a 1-year downtime, 9 flights the first year, then 14, and then 18.

Senator GORTON. That is overwhelmingly optimistic, is it not, at this point?

Admiral TRULY. Well, the direction that I have given is quite specific to the level II and level III organizations within the shuttle is to disregard any planning figures and go back to the situation that we find at hand and develop what we believe is a safe and sustainable flight rate. I must tell you, however, that I do believe it would not be as high as those numbers that I just gave you.

But I think that the shuttle will be a robust system. I think that there are adjustments primarily in the way that we do training loads and do our scheduling and look at the actual available people at the Cape, with varied shifts and so forth, and that we will have a robust schedule. But precisely what the rate is, I am afraid I could not answer that.

Senator GORTON. Well, in those assumptions do you assume any landings at Kennedy?

Admiral TRULY. I think that we will land again at Kennedy. However, there are a number of very difficult factors that make Kennedy landings not very enticing to me as we start up again. And those factors primarily are some difficulties that we have had on many shuttle flights with our braking system. We are moving out with improvements to a replacement braking system.

There are also difficulties with weather predictions at the Cape. However, I think there are also some operational things that we can do that will permit our landing at Edwards in the interim until we become comfortable with KSC landings again.

I think there are some things that we can do that will mitigate the effects of this on turnaround time. For example, if the primary mission of the flight is a satellite deployment, it is not necessary for us to fly our normal 7-day mission. We may very well be able to get that primary mission accomplished and land again in 4 days. With 15 flights a year and a savings of 3 days per flight, that is a month and a half of turnaround time.

I am not saying that precisly is what I would recommend, but we are going to look at it. So I think that we will be landing at Edwards for the next several flights. I think eventually we will return to Cape landings and we will, when the weather is good, even in the interim, and I see no safety problem with that.

Senator GORTON. Are you as optimistic as Secretary Aldridge that you can work out the Department of Defense preemptive rights and still have sufficient capacity for important NASA missions?

Admiral TRULY. I am. We have worked, as he mentioned, very closely and diligently together to try to solve that problem. I would make one distinction, however, that is sometimes lost in discussion, and that is that there is a difference between flight schedule and manifest. Flight schedule is my primary effort at the moment, and that is determining how to get a reliable, safe and sustainable schedule going.

Then we deal with manifests, and we do that by priorities, and national security missions obviously are our first priority, as they should be. But that does not mean that the several national security missions have to be the first that are flown or even appropriately would be the first. We have many customers and I believe in the first year or so of flight we will serve them all once we get flying again.

Senator GORTON. Secretary Aldridge, do you think when shuttle flights are resumed that we will use Vandenberg from the beginning?

Secretary ALDRIDGE. The Vandenberg issue is quite a difficult one, as you know. As Senator Riegle pointed out, we put about $3 billion into Vandenberg. Our plan was to fly about four missions per year out of Vandenberg, and that was under the assumption that we had a four-orbiter fleet that could support flights from both coasts.

The purpose of Vandenberg has not changed. We need Vandenberg to launch the high inclination orbits, and there is no alternative to that. The only alternative we have is that if we would convert the shuttle missions to an ELV capability out of Vandenberg—and for some of the payloads that we are talking about that is very expensive—if we thought we ever were going to have Vandenberg again for flying space station or SDI or for any other missions, the cost savings of closing Vandenberg and reopening it are offset by the cost of converting those payloads that would have flown on the shuttle to ELV's.

Right now, with the downtimes that are within the ball park of a year to 18 months of downtime, and looking at the cost and the capabilities that we need out of Vandenberg, right now we have no reason to change our course at Vandenberg to fly an orbiter out of there as quickly as we can, given the requirements for NASA to get a first flight out of ETR, and then to shift as soon as we can get an orbiter out there, checked out, do the flight readiness firing and the launch, because we need that high inclination and you cannot get that from the Kennedy Space Flight Center.

Senator GORTON. I have additional questions, but I have taken too much time already.

Senator Riegle.

Senator RIEGLE. Thank you, Mr. Chairman.

We are really into complex subject matter here, and I appreciate the work that both of you are doing, and I also want to just compliment the people that have been working to try to reconstruct events after the accident and have gone out and found most recently this critical piece of the booster rocket, which to me is a phenomenal accomplishment—to have managed to locate that after this very extensive search that has been under way.

I would just like in a sense to thank all those people that have been working so hard out there, who are faceless and nameless but who I think are rendering a great service to the country.

I would like your best personal opinion, Admiral Truly, from today——

Senator GORTON. Your timing was perfect.

Senator RIEGLE. This is what you get for being in the minority, you see.

Senator GORTON. I will go now to vote, Senator Riegle. Why don't you go on and keep asking questions?

Senator RIEGLE [presiding]. I would like to start with you, Admiral Truly, and ask your current frank personal assessment as to how much longer you think the shuttle is likely to be down. I mean, what is your best sense for when we are likely to be able to get back in the air with the shuttle?

Admiral TRULY. My best sense is that initialy—and I was not a party to these planning figures—we set in place two planning manifests shortly after the accident, one of a 12-month downtime and one of an 18-month downtime, will bracket the reality.

Senator RIEGLE. That is to be able to actually send up an operational flight?

Admiral TRULY. Yes, sir. That is between the accident and the first flight following the accident.

Senator RIEGLE. Not test flight—full operational fight?

Admiral TRULY. As a matter of fact, I am glad you asked that. The first flight will be an operational flight, although we have constrained it with a number of conservative ground rules, one of which is that we will fly a payload of a class that we have flown before so that it is one that we have previously flown, developed procedures for, both during the work processing and also flight crew procedures. I would say that a very high candidate for that flight now would be the TDRS, the tracking and data and relay satellite, which was a replacement for the one lost aboard *Challenger* in the accident.

We have previously flown that vehicle. We have launched it before, and I am perfectly comfortable with the first flight carrying that payload. I think that is likely.

Senator RIEGLE. So your best estimate as of today is that we are going to hit that 12- to 18-month window in terms of getting that launch off?

Admiral TRULY. It is.

Senator RIEGLE. Secretary Aldridge, what is your personal assessment on the same question?

Secretary ALDRIDGE. Well, I, it so happened, last week sat down with Admiral Truly, with his people, and went through the same data that he saw, and I share that view. I would perhaps, being a little more conservative and having to plan perhaps for the worst, would go toward the end of that window for my planning purposes, rather than the middle of the window. But it is not inconsistent with Admiral Truly's assessment of where we stand.

Senator RIEGLE. Now if I remember correctly you said earlier that if we are down a year that you will have 10 DOD launches stacked up, and I think you said if you were down 2 years you would have 20.

Secretary ALDRIDGE. That is correct—21.

Senator RIEGLE. So if we are down at the outer limit, 18 months roughly, I assume it is somewhere in the 15 range.

Secretary ALDRIDGE. Yes, sir.

Senator RIEGLE. Do I take that to mean that the DOD requirements would basically use all of the capability of the launch? In other words, you would need the whole thing.

Secretary ALDRIDGE. No, sir; there are ways that we can work around getting those 15 payloads. Some of those 15 payloads can ride-share with other payloads. For example, some of those 15 include the GPS satellite, which can ride-share with other NASA flights. So we will work with NASA to try to get those flights off as quickly as we can, realizing they have some pressures, realizing also that only two of the three shuttles can launch the heavier DOD payloads.

So we will have to work with them on making sure. The flight rate is one thing. The type of shuttle that is flown has to be another. And we have to turn those around, and it may be that we will need orbiter 103 for one DOD payload and maybe NASA needs it for the next flight, and then we need it again. So we have to work all of that manifesting together, and I believe we can share and compromise where we can.

Now there may be some instances—and Admiral Truly and his people clearly recognize that—when I say that is a priority, we have to fly it, it has to fly on that date or soon thereafter, and they try to accommodate us.

Senator RIEGLE. Now these roughly 15, let us say at a minimum 10—15 maybe—loads stacked up here that are DOD launch needs, would they in the aggregate, given the balancing act that has to go on, would they tend to use 75 percent, 80 percent, 90 percent? What rough percentage of the total capacity of the shuttle do you think you are going to require even with the mixing and matching strategy?

Secretary ALDRIDGE. I will probably have to correct this for the record, but I am going to give you kind of my general assessment. I would say about half of those would use the entire shuttle bay. The other half could ride-share with other payloads, either multiple shots per launch, maybe two or three of those GPSs in a single shuttle bay and that kind of thing. But I would say roughly half of them would be full shuttle payloads, which there would be no other riders other than themselves.

Senator RIEGLE. Then with the remaining half where you could work out a sharing arrangement would you probably need as much as half of the shuttle capacity or more than that or less than that, would you guess?

Secretary **Aldridge**. I would guess that probably a third, say, of the payload bay, for example, could be used for that particular satellite.

Senator **Riegle**. In other words, you need two-thirds and they take one-third?

Secretary **Aldridge**. No; we will need one-third.

Senator **Riegle**. And they could have two-thirds?

Secretary **Aldridge**. Yes, sir.

Senator **Riegle**. Now I am wondering have you had a chance yet, Admiral Truly, to take a look at non-DOD launches that are being stacked up here? If we had to try to fit in what is going to be waiting to go of the non-DOD sort in what he has just described as the amount of launch capacity that would be available for non-DOD activity, how do those match up?

Admiral **Truly**. The business of manifesting is an extremely complex one. However, with the backlog that we have, I think there will not be a problem, frankly, in the next 2 or 3 years of finding a payload that we have committed to to fit into the available space. I am speaking now of launches from the eastern test range that are going due east out of the Cape because we have a number of satellites that we have committed to and would have flown during this downtime that we need to fly that could go on essentially any due east launch out of the Cape.

Senator **Riegle**. Would this be NASA scientific research type launches or commercial as well?

Admiral **Truly**. They vary. All of the above. We have commitments for NASA payloads, for spacelabs, for communication, for foreign and commercial communication satellites, so the business of manifesting is a complex one, and it is one that we spend, the system spends a great deal of time, but basically it is one of looking for every available opportunity within the performance of the vehicle and making sure that particularly in a situation like this we get the higher priority ones off first.

Senator **Riegle**. I am going to have to leave to make this vote myself, and so we will go into recess until the first member returns, but what are you going to have stacked up at the end of, say, an 18-month delay here? How many planned NASA launches, non-DOD, are you going to have waiting to go that will have to go at some point? I assume some are going to get pushed out, and those people may have to go to alternative launch vehicles.

Admiral **Truly**. I do not have that number at my fingertips. If you will permit me after the recess to answer that question, I will be happy to.

Senator **Riegle**. I think it would be useful for us to know what the delay is causing in the way of things that are waiting to go.

Admiral **Truly**. I do not remember it precisely, but I will be happy to try to get that information for you.

Senator **Riegle**. The subcommittee will stand in recess briefly until a member returns.

[Recess.]

Senator **Gorton** [presiding.] Senator, I have a few more questions while we wait for Senator Riegle to return. Can you tell us about the likely impact that SDI requirements will have on DOD use of the shuttle? Is that factored into the expected DOD requirement of four to six flights per year, or would that be in addition?

Secretary ALDRIDGE. No, sir, that is included in the four to six flights per year that we are currently planning, and General Abrahamson—as a matter of fact, I talked to him over the weekend, and he is relatively happy with our planning figures for his missions in the near years. As we look out into the mid-nineties, I believe, depending on the success of the technology programs, we could expect that the SDI requirements could rise significantly beyond the flight rate that we are currently planning.

Senator GORTON. Admiral, according to your statement, the current store of U.S. ELV's has limited capability. What do you mean by that? What are those limitations?

Admiral TRULY. By that, I simply meant that in the numbers that we have on hand and the payload throwweight or capability that they have is limited as compared to some of the satellites that have been manifested on the shuttle and need to be launched.

Senator GORTON. Secretary Aldridge, according to your statement, if we do not take immediate corrective action, the longer term impacts can be quite severe. What would be the longer term impacts of not making decisions, basic policy decisions now?

Secretary ALDRIDGE. Well, there are two aspects of it. One is that if we do not expand our ELV industry and ELV capacity beyond that which has been currently approved, of course, those payloads that have been stacked up ready for launching once the shuttle is flying, the backlog continues to build because we had planned for a 24-flight rate on the shuttle before the accident, and we were going to use something like 9 to 10 of those flights per year for DOD payloads. If we do not get additional—and this is in addition to that which was going to fly on expendable launch vehicles, the CELV's and the Titan II's. So it is only 3 orbiters which cannot achieve the 24-flight rate we are going to start adding to the backlog, and we had planned to offload some of those 24 flights onto the ELV's, so what will happen in my estimation is that about 2 or 3 years after we start flying, it will be DOD flying the shuttle all by itself to meet our demands.

Senator GORTON. That is the bottom line.

Secretary ALDRIDGE Yes, sir.

Senator GORTON. What effect do you think the NASA DOD space transportation architecture study is likely to have on any administration recommendation for the reconstitution of our launch capability?

Secretary ALDRIDGE. Admiral Truly and I cochair that particular study, and we reviewed the results of that last week at Vandenberg. The answer is very simply none. The type of future capabilities that could result from that study are outside—let me put it a different way. The new capabilities do not substitute for additional orbiters or ELV's to start a recovery program. It is too late in time to be an alternative to a replacement orbiter or additional expendable launch vehicles. The process of that study is going very well, and we are looking into the future capabilities, which look very exciting, and with an objective, clear objective to get the cost of space launch vehicles down, and we are looking at not just the boosters that go with that but the entire logistics and support base necessary to get the total cost to launch space vehicles down hopefully by at least an order of magnitude. At least that is our goal. If we achieve 20 to 30 percent, we will be delighted, but the answer is, it will not have any impact. The only thing I can say is that the lessons that we have learned from this accident about mixed fleet, about redundancy and robustness, we are applying to that study for the future.

Senator GORTON. What about the idea of a privately financed shuttle? There are obvious budgetary advantages, but what are the likely disadvantages?

Admiral TRULY. That is an interesting subject, because of the intense interest shown in recent years, really, both in the executive and in the legislative branches of our Government, NASA went out, I believe, in December—I am sorry, in January of this year with a request for expression of interest by private firms, and received letters of interest from four different corporations or companies. We are considering going back out now with a request for proposal because, frankly, the only way that that can be assessed from a fiscal point of view is to be dealing with a specific proposal, and I am no economist, so frankly, an off the top of the head assessment of whether that would be fiscally in the interest of the Government and the people of the country in these times is one that I am afraid will have to wait. From an operational point of view, I see no particular problem in a privately funded orbiter if it were built and required to operate as a part of our fleet under the same priorities and safety regulations, and so forth.

Senator GORTON. Would the Air Force agree with that assessment?

Secretary ALDRIDGE. Yes, sir, we would not particularly care whether it was a privately financed orbiter or a NASA orbiter so long as we could meet our missions and we have the priorities and the bumping rights necessary for our missions when we needed to. So long as security is maintained, which we feel comfortable with with NASA, I do not have any concern other than the difficulty with the economics. I do not quite understand how we would sell a $2.5 billion orbiter for $1.5 billion and then guarantee a certain return on investment for an investor. I think I would like to buy some of that stock, but right now I would have no problem from a DOD point of view if NASA would operate it to our needs.

Senator Gorton: How do you both intend to utilize the two Deltas which were previously assigned, and the three partially built Deltas, and does TCI have any legal rights to the latter three?

Admiral TRULY. There are some Deltas available. They are committed to two SDI launches and two NOAA launches, and as I understand it, there are three partially completed vehicles and some piece parts for some future vehicles. In 1985, NASA and the Department of Defense signed a memorandum of understanding or agreement with the SDI office which essentially commits that hardware to the SDI program pending their decision as to whether they would in the future choose to use it, and in a sense it is a lien on the Delta hardware. The answer to your second question is, no, the hardware is the property of the Government.

Senator GORTON. Admiral, an earlier NASA decision to suspend the shuttle marketing activities is, I understand, being reconsidered. I wonder if you could give us the status of that decision and whether or not, as a result of the indecision to date, Great Britain has decided to fly its Skynet 4–C on Ariane. Are 4–A and 4–B still manifested on the shuttle?

Admiral TRULY. Yes, sir; they are. I would phrase our present position somewhat differently. I think it would be inappropriate at the moment for us to so-called market the shuttle when we cannot commit to a launch opportunity. In the case of Skynet 4–C, again, we have companies, both foreign and commercial, who need to get their completed satellites into space, and I think we are seeing a natural thing going on with the Ariane being in operation, and certain satellites taking the opportunity to book space on it.

Senator GORTON. Finally, I understand an agreement had been reached to fly NOAA's K, L, and M polar satellites on the shuttle. What is the status of launch for those three satellites?

Admiral TRULY. Sir, I am not sure. Could I submit that answer for the record?

Senator GORTON. Certainly. Of course you can.

[The following information was subsequently received for the record:]

Last fall, NASA and NOAA reached an agreement in principle on the terms for launching the NOAA, K, L, and M satellites on the Shuttle from the Vandenberg Launch Site, but formalization was still pending at the time of the Challenger catastrophe. We are still including these launches in our planning manifests for the Shuttle, but I am sure that NOAA is reviewing all of its options.

Senator GORTON. Senator Riegle?

Senator RIEGLE. Thank you, Mr. Chairman. I have some things to go into, but if Senator Hollings has not had an opportunity yet, I will yield to him.

Senator HOLLINGS. I appreciate it.

Let me follow up with respect to the private sector, and try to clear the air there a little, Secretary Aldridge. Anyone that would go into launch business privately would have to have marketing rights and they would have to have assurance that they could carry commercial payloads, is that not true, in order to make it commercially viable?

Secretary ALDRIDGE. Yes, sir. They would have to have a market there that they could compete with Ariane or anybody else for their share of the market. That is right.

Senator HOLLINGS. At the moment we are losing in that competition. Now, what makes us think that with those kinds of assurances it would be to the advantage of the Government? Do you see any advantage to the Government?

Secretary ALDRIDGE. Sir, I think the advantage that we could give the commercial ELV would be the following. As I take an example of the competition, which is a plan that we are thinking about now, we could guarantee a booster industry of any type a certain number of flights per year to launch DOD payloads, and let us say a number that is like four per year. We will buy, guaranteed, four of these boosters per year, and as I mentioned, one of the criteria for selecting that booster for DOD payloads is that it must have a variant which is capable of launching a commercial satellite.

Once we have paid the four per year and are maintaining the launch base for launching those vehicles, the incremental cost for them to sell that booster or a variant of that booster to launch the commercial satellite would be very attractive for that industry, and we believe that they could in fact then find that competitive edge to enter into that field so they could compete with Ariane once we have established the production base which is valid and required for DOD purposes only. Whether or not they entered that field would be their choice, but we need those additional vehicles for our purposes, and can justify the cost for our purposes only.

Senator HOLLINGS. But fundamentally it is to guarantee their production base.

Secretary ALDRIDGE Yes, sir, to have us provide that capability and production capacity so they can compete at the margin rather than at the beginning of the program.

Senator HOLLINGS. I think we have some additional witnesses today who we can discuss this with. If I am correct, you have just given one of them a contract for 10 boosters?

Secretary ALDRIDGE. Yes, sir.

Senator HOLLINGS. I think that particular witness would be delighted with your proposal. He is willing, able, and ready to go, because he has got a DOD contract in his back pocket. But the others do not have any, and I guess what they are going to really say—I am only guessing now—is, you give me the same kind of contract and everything else, which will pay for my my cost of producing and what have you, and then I will enter any kind of contract.

Secretary ALDRIDGE. Well, sir, the way we are going to handle that, if they want to play in that game, we will compete and have everybody compete on a fair basis, and we will pick the winner that can meet both DOD needs as well as have a variant for a commercial satellite industry if they want to enter that. That is fine, but we are going to do it under a fair and the American way, under competition. We will get the best deal.

Senator HOLLINGS. But you have got to be in a position to compete, which in this case means you need a productive base. That is what I mean.

Secretary ALDRIDGE. Yes, sir. There are enough variants of boosters available today. We think we have a very viable competition that can be held in that area.

Senator HOLLINGS. The reason I am asking is not to be fanciful. On Monday I was talking with the Secretary of the Navy and he is commanding a public shipyard which has been in open competition with Newport News. Recently, the public shipyard won a contract with substantially lower bid than the private contractor, some $224 million, to overhaul two Poseidon subs. In this case, we have been able to prove a public yard can do it much more economically than the private yard, and Coopers and Lybrand have certified those particular figures. So it is interesting. One Secretary is moving toward public production because it is cheaper. The other Secretary is moving toward private production because maybe it is cheaper. I am trying to get that clear in my mind, which direction am I going.

Secretary ALDRIDGE. The boosters are built commercially. They are built by commercial firms. In any event, the Government does not do any of this.

Senator HOLLINGS. Do they sell any commercially?

Secretary ALDRIDGE. I am not sure I understood.

Senator HOLLINGS. The boosters that are built commercially are not sold commercially, are they?

Secretary ALDRIDGE. No, sir. We buy them under contract.

Senator HOLLINGS. But do they sell them to anyone else?

Secretary ALDRIDGE. No, sir.

Senator HOLLINGS. Do they have any other customers?

Secretary ALDRIDGE. Not now. They do not.

Senator HOLLINGS. That is what I am saying.

Secretary ALDRIDGE. But the market will exist. If we are talking about in the future with the launch capacity that will now exist over the next 2 to 3 years with a significant number of payloads backlogged that will not be able to fly on the orbiter or ELV's, we believe that market will exist. There will be payloads sitting on the ground that can fly on commercially available boosters.

Senator HOLLINGS. Now, let us jump to the shuttle. Would you recommend that commercial payloads be prohibited from the shuttle?

Secretary ALDRIDGE. I think there is a time in which commercial payloads should be prohibited from the shuttle and should fly on expendables, but I think we have a commitment in the near term to these customers. We essentially have a contract with them, the commercial satellite builders, to launch their vehicles, and there is nothing we can do other than launch those on the shuttle in the near term.

Admiral Truly pointed out—I believe he shares this view. Some time in the future we ought to have those fly on commerical ELV's. The problem is, where do you transition between your commitment today and when you are not committed at all, and we have to work that out with our customers. We have a commitment. The Government has stepped up to a commitment with these people, and we cannot just let them go under because we decide not to fly them, but there should be a time picked when we will come off of flying commercial satellites on the orbiter.

Senator HOLLINGS. But realizing that and the fact DOD is going to be the predominant customer for flights in the near term, it just gets in my mind perhaps that the shuttle ought to be treated as a research and development vehicle, still in the R&D stage, rather than a commercial launch vehicle. You remember we got into this discussion in the Appropriations Committee hearing 3 weeks ago. Can you elaborate? Do you feel that the shuttle itself should be an R&D program or a commercial program?

Secretary ALDRIDGE. I think probably Admiral Truly can respond to that better than I, but let me just point out——

Senator HOLLINGS. He responded to it, and I keep reading his response, and I do not know what his answer is. I am going back to him in a minute to find out what the man really said. All right.

Secretary ALDRIDGE. We will give him another chance.

Senator HOLLINGS. Good. That is a very difficult question.

Secretary ALDRIDGE. Let me put it this way. The success of the Shuttle Program should be measured in its capacity to use that manned space flight system, its unique capability, man in space. Launching commercial satellites that can be launched with unmanned systems is not, in my view, an effective and highly necessary use of the Shuttle Program. We should be using the shuttle for its manned unique capabilities for all of the scientific and civil and, if necessary, DOD missions that need man in the system. But for a commercial satellite which is based upon essentially old technology compared to some of the newer things we are doing when it can be launched on an unmanned system to take the pressure off using this unique asset, then it ought to be done that way.

Senator HOLLINGS. I tend, Mr. Secretary, in that direction. Now, if that is to be the case, what we have to do in the Congress is to try to educate the public that the shuttle is a unique facility and it is one that is going to have to be paid for. In other words, it does not operate on a cost-benefit basis where we are going to come out making money on it.

I think perhaps we mislead ourselves. We bring pressure, perhaps, on ourselves. We bring, perhaps, pressure on NASA to launch. Admiral Truly is right on target. He continues to stay on a safe schedule, a safe schedule, and that would be with respect to research and development needs rather than the commercial cost-benefit basis. That is a good thing fo us to study and come down on, because we will have to educate the public on that.

Along that line, Mr. Secretary, since you are on the space policy task force, my understanding is that the hangup on forwarding the request from the executive branch is to where to get the money. In other words, the OMB, I am told, would like to take it out of the hide of NASA. I do not mean that as a harsh expression, but just get it out of NASA's budget. But if you need $5 to $8 billion to replace the shuttle, to do the repair work, the cost of the investigation, to order the ELV's and everything else, and your entire overall budget being seven, it can't be done. And having been one of the principle authors of the so-called Graham-Rudman-Hollings Act, I admonish that this particular program did not increase or decrease anybody's budget. It just said we must have truth in budgeting. You must pay for the programs. And this particular Senator is ready, willing, and able, and I think I can sell that to the public, the necessity of this research and development program and the need to pay for it. I can find that $5 to $8 billion. It is not very difficult. This wonderful stance against revenues and taxes sounds pretty, but it is unrealistic. When you have got a valid $5 billion cost, you must pay for it. Whether I pay for it with a little bit bigger percentage on the minimum corporate tax or an $8 a barrel of oil import fee, rather than $5 a barrel, I can pick it up, and I think I can get that passed. I am talking sense, not just dreamy talk.

And I hope if you are on that task force you tell them, do not hold it up over at the White House, because they have been arguing over a month. They have more or less informed the chairman, the ranking member, and myself of where they were and what was going to be needed, and it is a $5 to $8 billion package, and we do not have that much fat in the NASA budget. We need that money, and we need that program, and we are going to make some progress, I think, on this budget right soon, and we are going to be debating it on the floor very shortly.

Secretary ALDRIDGE. Yes, sir; we share that concern. We need to get it over quickly. The issue is quite difficult, as you know. It is what are we going to do and when are we going to do it, and are there any alternatives to meeting this launch capacity, and of course the latter and most difficult, how do we fund it? And it is unfortunate that we have had to struggle with those issues, and hopefully by the end of this week we will have that progress under way to get it to the President, get his decision, and get it back to Congress for review.

Senator HOLLINGS. In fairness, Admiral Truly, do you agree with Secretary Aldridge, or do you differ with respect to his assessment on the matter of being a commercial venture in principle or a research and development entity?

Admiral TRULY. I do differ somewhat, I think.

Senator HOLLINGS. In what respects?

Admiral TRULY. In my experience in the Space Shuttle Program it is not as simple as an R&D Program, a test program, or a commercial one, although I would not describe it as commercial. I have launched a communications satellite out of the payload bay of the shuttle. It is at geosynchronous orbit today operating. It was not an unsafe thing to do. It was not even a difficult thing to do. As a matter of fact, the customers to deal with in the space shuttle have generally seen the best customers to deal with, and the easiest ones have generally been the manufacturers of communications satellites.

So, I do not see a particular operational difficulty there. At the same time, I do think that if we could get over this, I will say again, I think the difficulty is the transition from a situation where our Nation when we get flying again in the shuttle has the capability to launch communications satellites, and we are attempting to transition to a period in time when the shuttle is not doing that, but that is being done by viable private industry. It is that transition that we are all struggling with, and some think that it can be done by fiat by eliminating flying from the shuttle, and some think it will be more difficult. I do not know the answer to that.

Senator HOLLINGS. Well, I am looking at the competition, Ariane. We are not saying there are any operational difficulties. Like you say, you have done it yourself. You know best. But we are looking at the competition that does not have the man, and this manned shuttle ought to be as a unique entity used just for those things that you need that kind of manpower whereby Ariane is taking over. They are outdistancing us. They are doing better business than the United States is commercially. They picked up a majority of that business last year.

I would think if I were going to get it for the same price, I would take the manned launch myself, if I were the customer. But what we are trying to do is get competitive, and looking realistically at needs, there are certain things that can only be done by a manned shuttle flight. Let us limit it to those activities for which you absolutely need the manned shuttle flight. Communications satellite can easily be done by the ELV's. That is what I am thinking out loud. You can correct that or comment on it.

Admiral TRULY. Again, it is the difficulty of the transition to get ourselves to the point that we have an industry that will compete with Ariane, without government subsidy, and not only with Ariane but with other foreign—other countries that have that capability.

Senator HOLLINGS. Thank you, Mr. Chairman.

Senator GORTON. Senator Riegle.

Senator RIEGLE. I will be very brief, because you will have some things—I am going to have a series of questions I am going to ask for the record that I think I can do just as well there, because we have got other witnesses that we want to hear today and we may get interrupted with other votes.

I am going to ask these questions as much or more for the record than I am for my understanding, but I think it is important that we have it on the record. Secretary Aldridge, what is the size of the Department of Defense space program today?

Secretary ALDRIDGE. In terms of dollars?

Senator RIEGLE. In terms of dollars, or any other way you would want to describe it, to give us sort of a bottom line.

Secretary ALDRIDGE. I can give you roughly, the Department of Defense is spending, I believe it is in the fiscal 1987 budget, roughly $15 billion across all the Department of Defense. That includes the Vandenberg, that includes booster procurements and the satellite programs that we have, about $15 billion and it is projected to grow through the next 5 years. I do not recall right offhand what the growth rate is, but it would be roughly the 3 percent per year, I would guess, over the next 5 years.

We are struggling right now with putting the next 5 year budget together as a result of the 1986 and 1987 budgets, and so I cannot tell you exactly what the rate is since we are working on it, but it is a growing budget for obvious reasons, and SDI, of course is included in that.

Senator RIEGLE. So, $15 billion would be the current figure?

Secretary ALDRIDGE. Yes, sir.

Senator RIEGLE. What would it have been 3, 4 or 5 years ago?

Secretary ALDRIDGE. I would guess about 5 years ago, it probably would have been in the $8 billion number.

Senator RIEGLE So, it's roughly doubled over that timeframe?

Secretary ALDRIDGE. That would include inflation, but it has gone up significantly.

Senator RIEGLE. Admiral Truly, what are the comparable number s for NASA?

Admiral TRULY. Our present budget, agency budget, is in the neighborhood of about $7 billion per year, and I do not know what the figures would be from 5 years ago but I will get them for you.

Senator RIEGLE. Now, to me this is a very important fact, and I think it is one the public does not really grasp, and that is that in a sense we have two space programs going. We have a Defense Department space program of very considerable size, in fact twice the size in dollars of the NASA Program, and we also have the NASA Program going.

Now, they obviously are interrelated. I do not mean to say they are absolutely discrete and separate because they are not, and it seems to me that that, by itself, poses some important questions that are partly framed by this accident, and the fact now that we are confronted with a decision as to whether or not we are going to rely very importantly on the shuttle and augment the shuttle fleet with one or two more over a period of time, or whether we are going to now move more in the direction of expendable vehicles and with the Air Force taking the lead in that area.

So, to the extent the Space Program takes a significant turn, it would be perhaps more in DOD's bailiwick than NASA's bailiwick. I think that is an important question. And then there is this sort of third question, and that is what is going to happen to the commercial business. Are we going to set ourselves up to really get into the commercial business in a big way?

If so, do we do it in the private sector? If not, what blend do we do it in the public sector, and who will do that? Presumably NASA does that, but if the Air Force is going to move in the direction of a very substantial expendable launch fleet, maybe they end up getting more into the commercial business from the point of view of the government doing it.

These are questions that are, I think, relatively new questions, and I am not comfortable myself now with the degree of knowledge that I think we have as to how to assess these things. I think today, if you were going to go out on the street and tell people that the Department of Defense has a space program that is twice as big as NASA, I mean, most people would think you were kidding because they do not know that, or they would find that a startling fact.

I guess I am wondering now how we are really going to integrate these activities as we go down the line. Obviously there are separate functions, at least to some extent, that need to be met separately. But in my own mind I am even beginning to wonder about economies of scale and duplication that may be arising, and I am not quite sure I understand how we are going to go down the road here, especially in light of the fact of the expendable launch program that we are talking about.

So, help me understand that better, Secretary Aldridge. How do you see this? You are running a big Space Program these days, twice as big as NASA, and if you can illuminate this for me in a policy sense so I can understand a little better how to make sense of this, and where do we go from here.

Secretary ALDRIDGE. Let me start off by saying, which is probably obvious, that space is becoming a more important part of the Department of Defense. It is unique. It has unique characteristics. It is cost effective to use space as opposed to other solutions.

It is clear we use space for monitoring arms control agreements. We use space for command and controlling our satellites and talking to our forces worldwide and reliably and quickly. We use space for weather. We use space for early warning systems. We use space for navigation. And, we are doing a lot of things in the research and development world to look at how we could use space better for the future.

It is interesting that what is happening to our Space Program, it is moving from a focus which has been more nationally oriented, helping the national command authority, giving him information, to one of helping better the military commanders in the field, giving that individual in the field more information about what is going on, what the enemy is doing, what is he like, what kind of capabilities and weaknesses do they have, and providing the necessary information to basically multiply the effectiveness of the forces that he has.

I can assure you, without going into details, space had a significant contribution to the attacks in Libya, in directly supporting the military commanders. So, the budgets are reflecting this change in emphasis from national focus to a more national focus plus support of the military commanders, an the need for enhanced survivability, redundancy and things like that.

What is happening is that we are seeing the natural evolution of growth, because we see the value of space to multiply the effectiveness of our forces in the future. So, I think that is the one trend you are beginning to see.

Now, in doing that, of course, we have had to introduce some new things. The Vandenberg launch facility which was not part of the budget 5 or 10 years ago, it is now there. We have had to put $3 billion to build that facility for the shuttle. We had a launch capacity for ELV's out at Vandenberg but not for the shuttle. And we have had to look at increasing costs per flight.

So, a lot of the budget is also reflected in the fact that in the 1970's we were paying $30 million a flight to launch a Titan 34 or Titan 3, and now we are paying, depending on whose numbers you want to talk to, probably $100 to $150 million to launch an ELV, and it is probably not that dissimilar for the cost of the shuttle once you put in all the overhead and things like that.

So, it is cost of launch—a lot of things are just increasing in price—and the change of emphasis. If you say, what is wrong with that, my answer would be, nothing. That is exactly the way it ought to be. We are getting a tremendous benefit from space for our country that we did not have 5 or 10 years ago, and it is worth the price.

Now, you asked the question, how can we make sure that we are not duplicating our efforts. There had been a lot of criticism about 2 or 3 years ago. It started with the ELV, that all the Air Force is after is to build its own space launch capacity.

And let me say, that was just untrue. We were not trying to do that. We foresaw the need, that we needed an ELV capability to complement the orbiter, and whether or not we had four orbiters today or not, we would still see that same need, do not put your eggs in one basket. And unfortunately, the tragedy—I think that issue is now behind us.

But in trying to work with the whole program, we are working very closely with NASA. We have this second generation space transportation study underway that is cochaired by Dick Truly and myself. We are working jointly on understanding the manifest on the shuttle to get the recovery program working. We are working very closely on that.

We have got a technology program underway that was started about a year or so ago to make sure that technology to support future generations of launchers are tied together and that is clearly the case. They are fully integrated.

I think the cooperation that you see, especially out in the field at Kennedy and at Vandenberg is phenomenal. You will never see a closer working relationship with two agencies, ever. Just visit Kennedy or go visit Vandenberg and see for yourself. It is something that is working.

Now, of course we do not do everything perfectly, but I think we have done just about everything I know how to do to make it as close to perfect as we can make it, and I am happy with the progress. I speak with Bill Graham quite often, and I think he is fairly happy with the progress that is being made.

Senator RIEGLE. Well, I can certainly see, and you describe many of the gains that we have gotten on the defense side on a worldwide basis in terms of moving into space with the technology and different things that we are doing and so forth. So, I think you can track how that has come about.

But as you play that on over into NASA, and particularly in light of the fact that once we are up and running again that you are going to have a minimum of ten launches ready to go, and maybe as many as 20 and maybe somewhere in that middle range, as we discussed earlier, some of those would have room for other things, either NASA payloads that are research-type or scientific-type or even, maybe, some commercial activity.

But even on the NASA side, it looks now, partly because of the accident, as if the DOD component is really beginning to tilt the equation pretty heavily that way, and other things are being squeezed out. And, one of the concerns I have, I would like to see us be in the commercial space launch business, and I say "we, 'I mean the United States. I am open as to whether we do it in the private sector or the public sector or whatever the mix is, and so forth.

But I really do not want to see that foreign competition take the leadership role. I think it would be a mistake, in a sense not quite the same mistake as not having the capacity to be first in military technology in space, but I think there are similar kinds of damages that flow out of the fact of ending up second in that area.

I do not want to end up second in that area in terms of commercial activity, and I do not want to see this thing get tilted so much one way, particularly because of the additional pressures of the accident, that we find ourselves with NASA in the traditional sense that I think a lot of the public thinks about it, as being sort of the tail on the dog in the Defense Department, and its needs are the dog and everything else is the tail on the dog, and I am not quite sure how we deal with it.

Secretary ALDRIDGE. Can I address that?

Senator RIEGLE. Yes, please.

Secretary ALDRIDGE. We are looking at this plan, which I mentioned before, and we are still working within the interagency to get the plan approved. We had two approaches the Department of Defense could have taken, and one approach is that, well, we'll just not do anything and use the orbiter to the maximum extent possible and just exercise our bumping rights with the three-orbiter fleet and fly them when we need to.

That would, of course, have been the minimum cost to the Department of Defense. We would not have to do anything other than what we are doing, just pay additional flight charges which we have already paid for anyway because we had planned to fly on the 24 flights a year, about one-third of them.

The other approach is, abandon the shuttle altogether, put everything on the ELV's, and we could do that. It would take a long time. It would be very expensive for DOD, and it would leave the orbiter fleet to fly commercial satellites and civil missions and everything else, and clearly, we could have done that and our ELV industry would have grown by a considerable margin.

We would be flying something maybe on the order of 10 or 12 ELV's per year of shuttle-size capacity, and of course the little ones, we would fly maybe 2 to 6 per year of the smaller sizes. That clearly did not seem to be the right answer either.

So, what we tried to do was, as I mentioned, a balanced approach. We took those payloads that could be easily and conveniently moved to ELV's that did not require a man in the loop, and we did move those. The other payloads that were more expensive and/or more costly in time and dollars to change from the orbiter to the ELV, we left on the orbiter.

And, I believe we have got a plan now that roughly balances. About 50 percent of our payload flights will fly on the orbiter and about 50 percent of our payloads will fly on ELV's. I think that is about the right balance.

Senator RIEGLE. I buy that principle of balance. I guess I am raising a different question, and that is, you know, the display you have brought of all the different expendable launch vehicles.

Most expendable launch vehicles are on the DOD side of the table, and they could just as easily be on the NASA side of the table. In other words, we could put NASA in the expendable launch vehicle business in a major way, rather than the Air Force and the Defense Department.

Secretary ALDRIDGE. Let me address—Thor Delta is used by NASA. The Atlas Centaur is used by NASA. Of course, the orbiter is used by NASA. And I do not believe there is anything else in there, although the vehicles are available to NASA for that purpose.

Senator RIEGLE. I guess that is my point, and that is one of the points I want to focus on, and I will yield here in the interest of time. But we must decide what is the policy decision we want to make as a country now. I think there is a lot of weight that supports this notion that we need to have a substantially augmented ELV capability and that we ought not to do things with manned craft that are not needed, things that we can do it perhaps less expensively on an ELV. And we can do more things if we beef up our capability in the unmanned area.

The doubt in my mind is to where you house this ELV capability and how that is done. What should be the role of the DOD Space Program and the role of the NASA Space Program is far less clear to me. You know, maybe what we ought to be doing, if we are going to go that route, is to think in terms of a restructuring of NASA.

Maybe the expendable launch vehicle activity ought to principally, primarily be focused there. In other words, I am still not clear in my mind exactly where we are today in terms of two separate entities, however closely related and however well they work together. When you realize we are up into these kinds of dollar totals, $15 billion for DOD and $7 billion for NASA, over $22 billion; it is a lot of money, and it is rising. This is an important question especially under the pressures of Gramm-Rudman-Hollings.

And so, I guess I buy the thinking in terms of the general direction of where it looks to me we have to go, but as to the structure and how we ought to be putting this together, both within the Government and outside the Government, is much less clear to me and I do not think we have debated that very much. I do not think we have looked at that very much.

I think it is more just a matter of momentum than it is any kind of a careful judgment as to where it is we want to be 5, 10, 15, 20 years from now. I just want to get that issue out on the table because it is one I want to think through and I think maybe we are all going to have to spend more time on it.

I would like to just conclude by asking you, Admiral Truly, whether you have any thoughts as to the NASA role with respect to the kinds of questions that I am raising here, for the future.

Admiral TRULY. I think this conversation clearly demonstrates the difficulty, pardon the expression, Senator Hollings, but the difficulty we find ourselves in as focused by this accident. As Secretary Aldridge says, I think the fact that the models are on his side of the table does not represent the integrated approach that the Nation finds itself in, as we have evolved in the short 25 years or so that this Nation has been in the space business.

The hugeness of the fiscal requirements of this program have brought us closer together. They have brought these policy issues to the forefront. However, I do think that a melding of the civil space program and the military space program, even though you might find that it made economic sense, would not make national sense.

There are objectives of space and, as was Secretary Aldridge, I am very familiar with the military uses of space, particularly those tactical uses with the Tactical Commander because of my experience in the Naval Space Command. But, it is larger than that, you know, planetary exploration, commercial satellites, space science, and we only a couple or 3 years ago changed the national policy prior to which the national policy was that the space shuttle would be the only access to space.

So, I guess the bottom line, in my view, is that as I stated in my opening remarks and that is that even though these are troubled times and difficult decisions, I think we need to debate them so that we emerge from this accident and after the recovery, and as we look to the future in a stronger position than we were before.

Senator RIEGLE. I agree with you, and I will just conclude by saying that I think your comment to the effect that we need a debate, I think is right. I think we are at a new point. I think there is the need for a debate, a discussion, an assessment of options, structure and purposes and balance as to how this is going to get done, that has not really taken hold yet.

I think there are a whole set of new questions that are now framed as a result of the accident, but which were part of what was occurring anyway. I think we are now forced to a point where we are going to have to sort that policy out with some very considerable care and not just have it be, in a sense, the sum total of a forward rush of events. And hopefully, we can all work together to get that done.

Senator GORTON. Senator Rockefeller.

Senator ROCKEFELLER. Mr. Chairman, I will be brief, as they say. I associate myself with some of the concerns of Senator Riegle, and in that line it comes down to the question of the Senior Inter-Agency Group for Space. As I understand it, it is a Cabinet-level group.

Secretary ALDRIDGE. That is correct.

Senator ROCKEFELLER. And it has a wide variety, Department of Commerce, DOD, NASA, Office of Technology, a variety of groups on it, representing different interests. Now, there is a history of inter-agency groups which is not necessarily successful in terms of clear decisionmaking process.

In fact, often when one charts an unsuccessful sequence of policy decisions, one can trace it back to an interagency working group which was formed because there wasn't any clear way to otherwise make policy. Now, I do not presume that is this case at all, but there is no question that following the accident there is a new emphasis on clear decisionmaking.

It is not just the accident, it is not just Gramm-Rudman-Hollings that is forcing new priority on clearer decisionmaking. I am not on the Senate Budget Committee, but one of the things that I am very impressed by, all of the other three gentlemen here that I am very impressed by, is the fact that under this new budget law that we are living with there seems to be a real emphasis on what really is important for the country. And, from the Senate Budget Committee emerged a truly bipartisan, carefully thought through, in my judgment, very workable document.

In any event, do you think—and whether it is difficult or not for you to answer, there is a lot of conversation now that the Joint Chiefs of Staff system and the constituencies represented there need to be reformed, and I would suppose that the public would have every right to ask, is our decisionmaking, policymaking on space policy, from the executive branch being made in the most efficient way, through the most efficient process or does it need to be reformed?

Secretary ALDRIDGE. I do not think you could look upon this, the SIG Space, as our ideal way of making decisions, or the quickest. But, there are a lot of affected agencies and affected interests.

OMB is interested because it has to follow tremendous budgetary pressures. The Department of Transportation is interested because they have the policy and the authority to work on commercialization of expendable launch vehicles. DOD obviously in there. NASA is obviously in there. The Department of Commerce is in there because of the commercial aspects of whatever we do. The National Security Council has obviously had quite an influence because they have to set the policies and modify any existing policies before—it is just a very difficult process, but each of those, if you said, who are we going to throw off the committee to make the process work any better, I cannot find one that does not have a legitimate concern in that process who ought to be listened to if they have a concern.

I think it is just unfortunate that we have not moved any faster, and that is just part of the bureaucracy. I wish we could have moved faster and gotten the issue resolved and over to Congress for resolution, but I do not have any better ideas of how one would do that.

Space policy starts with the President, and he has advisers that have to advise him on aspects of space, national security, commercial, civil, national interests, and the interests of our own commercial industry. So, I do not have any better solution than the one we have got. I think we could make it work better, but I would not change it.

Senator ROCKEFELLER. I think that is an interesting question because we are going to have to do better with our so-called oversight function. And you say, well, how are we going to have to do better? And the same question surfaces. We have our functions and processes and they work the way they do, but we are going to have to do better. One could easily argue, we did not do well enough.

I mean, was there enough thought really put in all of this. That is not to say that if the Congress worked 17 times as diligently, an accident could have been avoided. I am not saying that at all. But clearly, with something as expensive as we are contemplating, with the division of functions between NASA and the Department of Defense, as you have indicated—and that concerns me, as it does Senator Riegle, because if you are talking about manned flight in terms of scientific research, medical research, which I believe you were, Mr. Secretary, and then other things with respect to the ELV's, then how do you make that distinction? You both use the word "balance" a great deal and yet there you are talking about two clearly different functions and two clearly different agencies with two clearly, from now on, competing budgets under clearly, carefully watched moves by the public.

That question of balance, that question of decisionmaking, I think is—and oversight on our part, I think is a very genuine one, one that for the moment I obviously do not have any answers to but one which perplexes me.

I am not worried about which side of the table those rockets are on, but I think that the decisionmaking process symbolized by some of the previous questions are very important. I might ask one thing and say, with respect to those, Delta, Atlas, and Titan rockets, have there been any groundings of any of those? Is there any accident rate on any of those that——

Secretary ALDRIDGE. Yes, sir. As with any booster we have had problems, of course, in the early years of the space program. We lost quite a few. The most recent failure occurred last August. We lost a Titan 34D which is this vehicle right here.

It had a failure in the booster section of the rocket with a major oxidizer leak. We have gone back through that and done just about everything we know how to check it out, and we think we know what happened. We are not sure exactly why it happened.

Senator ROCKEFELLER. Are there similarities with the shuttle booster?

Secretary ALDRIDGE. No, sir. The rockets are built by the Chemical Systems Division in California. They are a solid rocket. You can see the difference. This is a much smaller rocket, much smaller in diameter. The joints are put together differently. I think there are 277 bolts around the solid rocket on the Titan 34D and 177 on the shuttle.

It has been proven technology, that Titan that was lost in August was the first failure in Vandenberg in 18 years of Titan launches. We have had remarkable success over the program, and we plan to refly it. We have done just about everything we know how to fix it, and we are confident that we have identified at least the area where it is a problem, and of course we are willing to take a little bit higher risk. There is no man on this. But, we felt that the reliability of the rocket has been extremely good, and we are willing to refly it.

Senator ROCKEFELLER. Just one more question, because you have both been here a long time and Senator Gore still has questions. The Vandenberg launching site, and I understand the trajectory reasons and all, but through a series of hearings it is becoming more and more to the fore as a concern. You very much indicated that, Admiral, today also.

Is it not correct, in that part of California there are problems with fog, cold weather and wind?

Secretary ALDRIDGE. There are problems with fog and high altitude winds. Cold weather is not that much of a difficulty but, yes, there are problems in that part of the world, or part of the country, and we have to tolerate that just as we do at any other place. We have got a long history of launching expendable launchers, launch vehicles out at Vandenberg.

Senator ROCKEFELLER. And you simply have no alternative?

Secretary ALDRIDGE. We have no alternative because of the high inclination orbits we have to fly from. Our rate that we were planning from Vandenberg was not very pressing. We were planning to fly about four flights a year out of Vandenberg at the time before the accident, and 20 flights a year out of Kennedy.

Senator ROCKEFELLER. Thank you, Mr. Chairman.

Senator GORTON. Senator Gore.

Senator GORE. Thank you very much, Mr. Chairman. Mr. Secretary, Admiral Truly, it is a delight to have you before the committee. I am sorry that I missed some of your testimony here, but I am glad to have a chance to be with you and read your statements.

I would like to ask just a couple of questions about foreign competition, if I might. I understand that the Swedes have just put down some earnest money with the Chinese for a launch. Is that correct?

Admiral TRULY. That is my understanding.

Senator GORE. For what kind of payload?

Admiral TRULY. I am afraid I just learned of that, and you have now exhausted my information on that. But I will get the information for the record, of course.

Senator GORE. That is fine. Thank you.

[The following information was subsequently received for the record:]

The Swedes have made reservations with China for the launch of Mailstar, in 1988. Mailstar is a small communication repeater satellite with a weight of approximately 200 Kg. The Chinese claim to have a contract for a dual payload launch. The second payload is reported to be a Chinese Earth resources satellite.

Senator GORE. So, that is a new competitor. What foreign launch systems are currently operational, if you could list them all?

Admiral TRULY. I cannot list them all by booster title, as we normally refer to them in our acronyms here, but the French Ariane is obviously in operation and has a large share of the commercial market. You mentioned the Chinese program, and as I understand it, representatives from China are in this country this week, discussing possible launch opportunities with United States satellite manufacturers. The Japanese are coming into the ELV business. And, of course, the Soviet Union.

Senator GORE. Any additional Government-sponsored ELV's expected to emerge, other than the ones you have just mentioned?

Secretary ALDRIDGE. I think we would hope that through a plan that we have discussed earlier in the hearing, that if we went under an expanded ELV Program of our own, that variance of those programs could be made as viable commercial satellite launchers by the U.S. industry, that could compete economically with the boosters of the other countries that were mentioned.

Senator GORE. Would we be required to subsidize commecial ELV's to make them competitive with these ELV's from the other countries?

Secretary ALDRIDGE. It is hard for me to say. What do you mean by subsidize?

Senator GORE. Give them money.

Secretary ALDRIDGE. We can justify an ELV industry to support DOD missions alone and provide a production base to build those vehicles for DOD payloads. Then, once that production base is established as well as the launch base to launch those vehicles, then the issue becomes, does that commercial company which builds the satellites under Government contract have a viable candidate for a commercial ELV to support commercial satellites?

Senator GORE. Having already amortized their costs with DOD?

Secretary ALDRIDGE. We have provided the production base which we justify on our own. I would not call that subsidy, but it certainly provides the entry price into the field, which then makes it very attractive for that industry to sell, on an incremental basis, the cost of booster for commercial.

I will give you an example, however, why that benefits us. We do have a program, which is this commercial or complementary ELV, which we are going to fly about two per year. If Martin Marietta who builds this rocket could sell additional rockets to—for commercial purposes, they would give us a certain amount of money back because they could amortize the additional production rate over additional flights and the DOD would benefit because the unit cost would drop for our flights as well.

I am not sure the market is there for that purpose, because we are looking at expanding this ourselves to offset some of the down time and launch rate losses that will occur as a result of the accident.

Senator GORE. Now, you are handling the 34D7 there?

Secretary ALDRIDGE. That is right. That is a Titan 34D7 vehicle with a payload capacity and size that is equivalent to the shuttle bay.

Senator **Gore**. To ask the same question asked before in a slightly different way, why is it that no U.S. firm has been able to market a commercial ELV launch?

Secretary **Aldridge**. I can give you an estimate. I think that is probably better answered by NASA, but I believe that the market with the capacity that existed, or planned capacity that existed in the shuttle, was such, and the rates that we were providing, the launches to commercial satellite owners, were such that a commercial ELV could not compete in that market against the shuttle or against a subsidized Ariane.

Senator **Gore**. Well, during this hiatus and during the prospective reduction in shuttle capacity for some time, will that change or will the second factor you mentioned, the subsidized competition, continue to render—continue to make it impossible for a U.S. company to market a successful ELV launcher?

Secretary **Aldridge**. I have an opinion on this. Right now is the opportunity for us to aggressively move out into a commercial ELV industry. We will need more ELV's. We will provide the production capacity necessary to sell ELV's for commercial satellites at a very economical rate. And we have a golden opportunity right now, and we should step up to it and move out.

Senator **Gore**. I understand why DOD is thrilled at that prospect, but why would a company not be daunted by the subsidized competition?

Secretary **Aldridge**. Because the market is there. If I looked at the Ariane launch capacity that currently will exist over the next couple of years, I am sure they are looking at how they could enhance it. But it looks like the Ariane is essentially saturated with maybe one or two additional launches it could launch.

Any additional commercial satellite that is not going to be able to fly on the orbiter cannot necessarily be picked up by Ariane. Some of the other users might be able to pick it up, such as the Chinese or Japanese.

But if the market is there, which I believe it is, and we could make it attractive in this country for a company to enter into that field, I believe the market will drive them in that direction and if we say at some time in the future when the ELV industry is in fact in place that the shuttle will not fly those commercial satellites, I think the people I have talked to in the industry will jump into the marketplace with a viable commercial ELV.

Senator **Gore**. Well, I hope you are right, but uncertainty is itself an obstacle. And, as I am sure you are aware, the major market model used is the Battelle model in this area, and it has been off by 50 percent in recent years, and I do not know if there is any remedy for that.

I can only say again, I hope you are right in your predictions. Would you like to add anything to that, Admiral Truly?

Admiral **Truly**. I think you have asked the $64 question. As I have said earlier today, I think the difficulty is not the desire of all of us as to the final result that we have a viable commercial ELV industry, but the interim period. It is certainly my view that our first obligation is to those U.S. and other customers that we have booked on the shuttle to make sure they get flying. When we do we can assist them in getting other access to space.

It is this interim period that has me puzzled, and is the one that I think is debatable, whether or not with the shuttle out of the competition a company in the free marketplace can be viable and compete with foreign—or government subsidized foreign capabilities.

Senator GORE. Thank you, Mr. Chairman.

Senator GORTON. Thank you both very much. The subcommittee has held you here for a considerable time this afternoon, but you have been of great help to us. We appreciate your being here. You will get more questions in writing, as you know, and we would appreciate your answers to those questions.

Secretary ALDRIDGE. Thank you, Mr. Chairman.

Admiral TRULY. Thank you, sir.

Senator GORTON. Ms. Johnson from the Department of Transportation. Thank you for your long wait. You may proceed. Your full written statement will be included in the record.

STATEMENT OF MADELINE JOHNSON, DIRECTOR, OFFICE OF COMMERCIAL SPACE TRANSPORTATION, DEPARTMENT OF TRANSPORTATION

Ms. JOHNSON. Yes, sir, Mr. Chairman. I understand that. It is a pleasure to be here today to appear before you and the members of this subcommittee. With your permission, I will summarize my testimony and submit my full statement for the record.

Senator GORTON. Please.

Ms. JOHNSON. The tragic loss of the space shuttle *Challenger* highlights the risk in continuing to rely upon any single launch system for providing assured access to space. This unfortunate hiatus in American launch activity provides ample evidence that this Nation needs an unmanned, expendable launch vehicle complement to the shuttle.

Current estimates indicate that the shuttle system will be grounded for at least a year. It is clear that the backlog of payloads that will result will exceed both shuttle's and Ariane's capacity for launching them for the foreseeable future. While the free world's only commercial launch system currently available to put satellites into orbit is the Ariane, its capacity is limited.

Other countries, such as the Soviet Union, China, and Japan appear to be eager to enter the launch vehicle market, but significant technology transfer barriers, together with their late entry into the world market and other considerations, will likely prevent them from becoming major providers of launch services in the near future.

If production began today, some U.S. ELV's could be available to commercial customers in 2 to 3 years, offering additional capacity for getting Government and commercial payloads to orbit and easing some of the pressure on the shuttle launch schedule.

American manufacturers have the advantage of 25 years of experience, hundreds of launches, and success rates in excess of 95 percent. As contractors to NASA, they have established relationships throughout the international satellite community. U.S. firms have the resources and expertise necessary to make a successful transition from Government to commercial operation of expendable launch vehicles.

A commercial launch industry in the United States would provide the Nation with a range of launch vehicles for assuring access to space. The existence of a domestic industry would diversify the base of resources upon which the Nation can rely for innovation and investment in space transportation.

Senator GORTON. You really did summarize it. That is greatly appreciated.

Ms. JOHNSON. It is my pleasure.

Senator GORTON. Ms. Johnson, what has retarded the development of the U.S. commercial ELV industry, and what is the most important factor or factors required to get the industry on its feet?

Ms. JOHNSON. The development of the industry has been retarded because it has not received a clear signal from the U.S. Government that the Government will not compete with it. It would be that signal which would allow it to get started.

Senator GORTON. Are you convinced that if it got that signal, it would be successful?

Ms. JOHNSON. Yes, sir, I am.

Senator GORTON. Do you want to amplify on that a little bit, or is that an unequivocal statement?

Ms. JOHNSON. Now I am going to equivocate a little. "Successful" is a tough term to measure at the outset, but what you are looking at here are three established companies that have long records of experience in this business, that have lines that are open or can be opened to manufacture expendable launch vehicles, to step into the breach and provide some commercial expendable launch vehicles at no expense to the Government. This will essentially ease this pressure that NASA has been put under to be all things to all users.

Senator GORTON. It is widely known that the SIG Space discussion about reconstituting our national launch capability is also focusing on whether or not the shuttle should launch commercial communications satellites. What are your thoughts on this subject?

Ms. JOHNSON. That is a part of the process within the SIG Space, and as the decision, the final decision of the SIG has not been made, it is difficult for me to talk about it in any great detail.

However, the key to this entire question, at least in the short term, is easing the pressure that has been brought to bear on NASA. If you look at the backlog charts it is hard to not see that expendable launch vehicles will be a part of that formula.

Senator GORTON. Well, if we do decide to go in that direction, what happens to satellite operators and upper-stage manufacturers who made major investments in developing technologies which are shuttle unique? Do we simply abandon them? Do we make exceptions for them? What do we do?

Ms. JOHNSON. I think that if you were to ask those manufacturers whether or not they are shuttle unique and do not have a compatibility to be launched on the French system, which is an expendable launch vehicle system, you would discover that indeed there is generally dual compatibility. And If those companies do not have that compatibility, I would suspect that in this time of shortfall with regard to the shuttle, they would be seriously considering establishing that within the scope of their business plans.

Senator GORTON. So, you are telling me, this is not even reflected as an issue?

Ms. JOHNSON. I think it is an issue. I do not think it is a reason to decide not to include commercial expendable launch vehicles as a part of the recovery formula.

Senator GORTON. Can a U.S. commercial ELV industry effectively compete with the subsidized foreign launch vehicles?

Ms. JOHNSON. Yes, sir, it can, the reason being that the foreign launch systems do not have the capacity to monopolize the market. The Ariane system has taken about 45 percent of the market away from the shuttle and it is essentially stretched to its capacity at this point.

Ariane presently has no plans to expand its system, but even if it did it would require a large up-front capital investment and a general investment of time and energy to involve the ESA member nations in expanding that capability.

Senator GORTON. So, Ariane can get everything it wants and we will get everything that is left over?

Ms. JOHNSON. Ariane is presently booked to capacity, so I am not sure that we would get what is left over, but I think that we could certainly be competitive for the remaining sector of the market.

Senator GORTON. What assurances do you have? Let us go back to my first question, and your quite unequivocal answer. What assurances do you have that any of the current U.S. ELV manufacturers are willing to make the market investment required to pursue the market, even if we have a clear and unambiguous policy?

Ms. JOHNSON. The manufacturers themselves have assured us at the Department of Transportation that, given a clear policy signal that the Government will not compete, they will step into the breach and begin to compete actively for those payloads on a commercial basis.

Senator GORTON. Thank you.

Senator Riegle.

Senator RIEGLE. Thank you, Mr. Chairman.

Let me ask you this: If what you are seeking were forthcoming, how long would it be before we would see private launches being made here?

Ms. JOHNSON. If we gave them a clear policy signal today, I think we could see launches beginning late 1988, and in full force in 1989.

Senator RIEGLE. In late 1988?

Ms. JOHNSON. Yes, sir.

Senator RIEGLE. You know, that seems like a long time from now. What kind of capacity would we have then, beginning in late 1986, stretching out the year or 2 years beyond that?

Ms. JOHNSON. The capacity is essentially a function of the demand, and it would obviously start out more slowly and build, depending on what the demand for the vehicles is. The transition period, this 2-year period, has been caused essentially by our collective shortsightedness, with regard to not having multiple systems for access to space, and if we are able to correct that mistake now and develop this capability on a commercial basis, I think that our commercial systems can compete with any in the world.

If we do not develop that capability, I would predict that other systems in the world will step up their activities and their interests and compete more actively sooner, and take the market share away from us.

Senator **RIEGLE**. I would be interested in having us develop a commercial capability, if that could be done. It seems to me, the practical way to try to get it done is not an all-or-nothing arrangement but some kind of joint arrangement where the government and whoever was going to do this in the private sector would formulate a cooperative venture.

I think there would have to be locked-in arrangements ahead of time with either financial help or a certain amount of guaranteed business or certain other things that made this feasible, in other words, that it was not just sort of a leap into the dark.

I am open to considering that, just speaking as one member of the subcommittee, but I think that is something different than what I hear you talking about. I would think that what ought to be done here is, you ought to see if you can develop some kind of a proposal with somebody or a group that involved that kind of a sharing of this effort, and I think if you can find people that are willing to do that, and if you can put yourself and your other staff people to work in some creative way to come up with something along that line, I think that would merit a look. Otherwise, I think the pressures of time and circumstance probably sort of run right on past us here.

Ms. **JOHNSON**. Senator Riegle, we have looked at that as a possibility, and have concluded that that creates a lot of unnecessary steps. This industry has been around for 25 years. The technology is proven and it is reliable. The people who are in this business have been doing it for the past 25 years. They know their business. They have contacts around the world because they have worked with NASA and to some extent with the Department of Defense, and they are ready to step in at this time.

Certainly, a transition period is required in order to establish a smooth transition for any of the communications satellites which are presently manifested on a shuttle, and the shuttle will have to launch any number of those.

Senator **RIEGLE**. It seems to me that if there is this commercial capability, and I am not questioning whether there is, that this is the perfect time to dive in. I mean, why not dive in? The shuttle is down. It is going to be down for a long period of time. When it comes back, DOD is going to basically take most of the business.

You have got business moving to foreign suppliers. I mean, if this was a private sector bonanza, it seems to me you would not have to sort of hang it out there for people. They would be moving toward it. And I gather they are not because the financial threshold here is such that unless they got some kind of collaborative arrangement with the government in detail, spelled out, it probably is not feasible unless somebody else has a head start in some other way where they have got some other sort of connection working for them.

So, all I am saying, I am trying to give you what I think is a piece of constructive advice and that is, I think that if you could put together something that really looked like it could work, in terms of a joint arrangement where somebody would say, look, I really want to come into the act, and if we could work out arrangements like this we would be prepared to do it and spend some major private sector money, then I think that is something that would get a serious look, especially now.

Ms. Johnson. Senator, the up-front costs are certainly part of the consideration here, and the industry is not willing to sink those costs into a private sector effort unless they are sure that the Government is not at some point in the future going to step in and compete unfairly. It is that policy signal and that policy signal alone which is keeping this industry from actively stepping into the breach.

I might add, however, that representatives from the three companies, Martin Marietta, General Dynamics and Trans-Space Carriers are already actively marketing their vehicles.

Senator Riegle. We are going to have a chance to hear a little bit from them today, so they will have a chance to tell us.

Ms. Johnson. I would make an offer, too. That is, we have done so much work in our office with regard to this, if you would give us a little time to sit down and talk it through with you, I would be happy to do that. I think there are some answers here.

Senator Riegle. Fine.

Ms. Johnson. Thank you.

Senator Gorton. Senator Gore.

Senator Gore Thank you very much, Mr. Chairman.

Would you agree that the handling of the Landsat decision was not a model to be used in the future, for giving the right signal?

Ms. Johnson. Senator Gore, I have to confess that I do not know enough of the details of the Landsat decision to be able to discuss that intelligently. I would, however, be happy to submit my answer in writing.

Senator Gore That will be all right.

[The following information was subsequently received for the record:]

Under the Land Remote-Sensing Commercialization Act of 1984 (P.L. 98-365), the Department of Commerce has been actively seeking to commercialize the LANDSAT program. This program includes the operation of two orbiting satellites, construction of replacement satellites, and development of a ground center. After a competitive bidding process, Commerce contracted with the Earth Observation Satellite Company (EOSAT), a partnership formed by Hughes and RCA, for LANDSAT commercialization.

The EOSAT agreement was premised on continued Federal support beyond the transfer of the Landsat system to the private sector. No such Federal payments have been requested by companies seeking to launch Government-developed launch systems on a commercial basis. The ELV commercialization initiative relies on private investments to produce commercial expendable launch vehicles. The initiative is premised on the expectation that demand for ELV launch services will be sufficient to prompt the development of a viable, competitive commercial launch vehicle industry.

Senator Gore I will take that as a yes.

Are there any actions on the part of this subcommittee and the Congress that you would recommend to ensure the emergence of a viable commercial ELV industry?

Ms. Johnson. Yes, sir. First of all, as I mentioned to Senator Reigle, we have done quite a bit of work in our office with regard to this and have an awful lot of information we would like to share with you. So if you are interested, we would love to come by and present our case. But second, it is absolutely imperative that the United States Government speaks with one voice to the industry.

If we equivocate, if we are afraid to step up to bat and give the industry a clear signal, then we will find ourselves dependent on a single system of transportation to space once again and that, as we all know, is not a good place for this country to be. It chips away at our ability to be the preeminent leaders in space exploration and development.

Senator GORE. Are there any actions that you would recommend at this time on the part of the subcommittee?

Ms. JOHNSON. There are no specific actions at this time. Once the SIG Space decision is made, I think there will be plenty of opportunity.

Senator GORE. When is that going to be made, incidentally?

Ms. JOHNSON. I cannot say exactly when it is going to be made. As Secretary Aldridge mentioned, the SIG Space meeting is scheduled for this Friday. This is considered to be the meeting at which decisions essentially will be made, and if that occurs then I think it will bump right on up to the President.

Senator GORE. What effect would a prohibition on shuttle launches of communications satellites have on efforts to obtain private sector financing for a new orbiter? I am not recommending that.

Ms. JOHNSON. Would you restate your question, please?

Senator GORE. What effect would a prohibition on shuttle launches of communications satellites have on efforts to obtain private sector financing for the new orbiter?

Ms. JOHNSON. For a new orbiter—I think the two are basically unrelated. Private sector financing for the orbiter is, as was discussed earlier, a difficult kind of a formula to put together.

Commercial communications satellites would be launched independently of a decision to privately or publicly fund a replacement orbiter.

Senator GORE. Well, I do not see how they could be unrelated. If SIG Space is considering a prohibition on shuttle launches of communications satellites, that would certainly seem to be relevant to efforts to get the private sector to participate in financing the new orbiter, wouldn't it?

Ms. JOHNSON. Even if commercial communications satellites or commercial and foreign payloads are offloaded, there is such a demand for the shuttle system, if you look at the backlog numbers, that I think there would be plenty of opportunity for the replacement orbiter, whether funded publicly or privately, to fly.

Senator GORE. The backlog is not directly related to the kind of marketing rights that investors would want, if you see what I mean. I mean, when you are talking about additional DOD payloads, it is different from going out and competing for the communications satellites. And if private sector investors are going to be urged to participate and then at the same time they are told that they are not going to be able to market launches for communications satellites, it seems to me that that is a conflict.

Would you agree?

Ms. JOHNSON. There are a couple of things there. I would submit that if private sector funding of an orbiter were to depend on revenues from launching commercial communications satellites, the private sector would not invest their money under our present pricing policy because they would not see much of a return coming back.

Senator GORE. I am not talking about depending totally on them. We are talking about the margins here. We are talking about the things that affect this decision to invest or not.

Ms. JOHNSON. Again, I do not see that commercial communications satellites have to be part of the formula for full use of a replacement orbiter. The shuttle system is looking at such a large backlog that if we were to ease the pressure on that backlog in any way, there would still be plenty of activity for the shuttle.

Senator GORE. Well, I could see your point in the short term, but presumably the backlog is not going to carry over for that long a time, and when you are making an investment decision of this magnitude you are going to look at the period beyond the time when the backlog is whittled down and then you are going to be looking at marketing rights and comparing that to what has been declared off limits.

Ms. JOHNSON. It is tough to say how long the backlog is going to be a part of the formula. But even with a replacement orbiter, we see a substantial backlog well into the 1990's, using a one-year downtime as an estimate. The longer the shuttle system is down, the bigger the backlog and the longer it will take to fly it off.

There are any number of factors which have to be considered by a group of private investors with regard to the shuttle system itself. Certainly, some of those relate to what the recommendations of the Rogers Commission will be with regard to the safety and soundness of the orbiter and the launch system.

Senator GORE All right. I apreciate your responses.

Thank you, Mr. Chairman.

Senator GORTON. Thank you very much, Ms. Johnson. We appreciate your being here. We will have more questions for you, and we will be happy to get your answers to them.

Ms. JOHNSON. Thank you.

[The statement follows:]

STATEMENT OF MADELINE JOHNSON, DIRECTOR, OFFICE OF COMMERCIAL SPACE TRANSPORTATION, DEPARTMENT OF TRANSPORTATION

Mr. Chairman, I am pleased to have this opportunity to appear today before the members of this committee.

Two years ago, the Federal government began to clear the way for the development of a commercial space launch industry. Working together, this Committee and the Administration have taken positive steps to create the conditions necessary for that industry to emerge. With the President's decision to give DOT lead agency responsibilities and your leadership in drafting the Commercial Space Launch Act, a fledgling private sector launch industry has begun to take form.

The competition from government-sponsored launch systems, both here and abroad, caused some to doubt that private sector firms could compete successfully in the international market. Today, however, we find ourselves in a very different environment. The demand world-wide for launch capacity exceeds it availabitily.

The tragic loss of the space shuttle Challenger highlights the risk in continuing to rely upon any single launch system for providing assured access to space. This unfortunte hiatus in American launch activity provides ample evidence that this Nation needs an unmanned, expendable launch vehicle complement to the shuttle.

Current estimates indicate that the Shuttle system will be grounded for at least a year. It is clear that the backlog of payloads that will result will exceed both Shuttle's and Ariane's capacity for launching them for the forseeable future. While the free world's only commercial launch system currently available to put satellites into orbit is the Ariane, its capacity is limited.

Last year, in testimony before the Congress, Arianespace officials discussed their plans to launch six to eight vehicles per year through the end of the decade. At that time, they indicated that, during the 1990s, Arianespace planned to decommission the ELA-1 launch pad and rely on the Ariane 4 vehicle to support approximately ten launches per year. Increasing that launch capacity would require substantial investments in production capacity at supplier facilities spread across eleven ESA-member nations, payload processing and integration capacity, propellant storage capacity, in addition to upgrading the ELA-1 launch pad.

While other countries, such as the Soviet Union, China, and Japan appear to be eager to enter the launch vehicle market, significant technology transfer barriers, together with their late entry into the world market and other considerations will likely prevent them from becoming major providers of launch services.

If production began today, some U.S. ELVs could be available to commercial customers in two to three years, offering additional capacity for getting government and commercial payloads to orbit and easing some of the pressure on the Shuttle launch schedule. American manufacturers have the advantage of twenty-five years of experience, hundreds of launches, and success rates in excess of ninety five percent. As contractors to NASA, they have established relationships throughout the international satellite community. U.S. firms have the resources and expertise necessary to make a successful transition from government to commercial operation of expendable launch vehicles.

A commercial launch industry in the United States would provide the Nation with a range of launch vehicles for assuring access to space. The existence of a domestic industry would diversify the base of resources upon which the Nation can rely for innovation and investment in space transportation. We are certain, as are the companies that will present testimony later this afternoon, that American ELV operators could provide the additional launch capacity necessary to meet this Nation's launch needs and be viable competitors in the international market.

The Department of Transportation remains convinced that the United States must continue to advocate policies that foster a private sector space transportation alternative. We have been active in the deliberations of the Senior Interagency Group on Space and the Economic Policy Council's Commercial Space Working Group, chaired by the Department of Commerce. In addition, we have worked closely, in an advisory capacity, with the National Commission on Space and as contributors to the joint NASA/DOD Space Transportation Architecture Study.

We have also focused attention on the impact of various regulatory requirements on commercial launch activities. As the Congress itself recognized in enacting the Commercial Space Launch Act, regulatory policy must be carefully crafted both to protect important national interests and to avoid stifling this industry's creativity and enthusiasm. Our regulatory approach is designed to provide an environment conducive to growth and innovation while ensuring safe and responsible commercial launch activities.

On February 26, the Department published an interim final rule that provides companies with the guidance they need to conduct effective planning and to secure expeditious review of their proposals. We believe that the policies and procedures contained in the regulations ensure that these proposals are efficiently but thoroughly scrutinized in order to protect important national interests—public safety, national security, and foreign policy concerns.

In addition to developing licensing policies and procedures, we have begun a comprehensive research effort aimed at developing substantive safety standards. This effort will include analysis of range and flight safety practices currently used at Government launch facilities. We will also conduct independent research to assist us in establishing safety criteria appropriate for commercial launch operations. Such criteria will guide industry in planning cost-effective launch proposals.

We believe that the approach taken by the Department has enabled it to carry out its responsibilities on the most efficient scale possible. In FY 1987, the President's Budget includes a request for $2,275,000 to support the activities of the Office. Most of this funding is dedicated to conducting the safety research that will enable us to develop the standards that will be applied to commercial launch operations.

Even before the passage of the Commercial Space Launch Act in 1984, industry plans for conducting commercial space launches were ahead of Government's plans for their regulation. Given current capacity constraints, we anticipate an increase in commercial launch activity as ELVs, in particular, play a larger role in assuring access to space.

This is a time of transition for our Nation's space program. It seems clear that a mixed fleet of both manned and unmanned, public and private launch vehicles best ensures that the Nation will have the transportation options it needs to carry out the full array of planned space-based activities. A competitive ELV industry will strengthen our industrial base, ease the burden on the taxpayer, better enable the U.S. to compete against foreign launch vehicles, and promote technological innovation and commerce.

I look forward to continuing to work closely with the members of this committee as we seek to strengthen America's leadership in space through the combined energies of the Federal government and private enterprise.

[The following information was subsequently received for the record:]

Questions of Senator Gorton and the Answers

***Question.* Do you believe that we need a replacement orbiter?**

Answer. The Administration position on this matter is presently being discussed within the National Security Council, and it would be inappropriate for me to comment.

Question. At a hearing before this Subcommittee last week, several witnesses from the space science and applications communities said that NASA should reinstitute an ELV capability.

Do you agree, and if this were to happen, how would it affect the U.S. commercial ELV industry?

Answer. To our knowledge, NASA has given no indication it plans to reinstitute an ELV capability. It is clear, however, that this nation needs a mixed fleet of launch vehicles.

The private sector has been providing NASA with launch services for over 25 years. There is every reason to believe that private firms are capable of providing these services to commercial customers directly, without the public having to subsidize the service. These firms have expressed a strong willingness to make the necessary investment to provide commercial ELV capabilities. Officials of these firms have consistently stated, however, that they would not make these investments if they would have to compete with the U.S. Government.

Question. What is your assessment of the market for a commercial ELV industry over the next five years? Ten years?

What effect will the emergence of fiber optics technologies have on this market?

Answer. We believe the shortage of shuttle launch capacity that will exist over the next five years creates a significant opportunity for a commercial industry to become established, if proper government policies are put into place. Ariane capacity is limited. The Japanese vehicle upon which they would base their commercial launch capability will not be perfected until the early 1990s.

The situation for a 10 year horizon is more difficult to forecast. Over that period the U.S. commercial operators will have had considerable opportunity to build up their clientele and make technological improvements necessary to meet the market requirements and get their costs down.

The emergence of fiber optic technology has made the telecommunications market more competitive. Satellites will always have a place in the market, however, because of their inherent cost advantages in single-point to multi-point communications, service to rural and remote areas, mobile sources and receivers, and over very long distances.

Question. You have stated that Arianespace will surge to about ten launches a year and that Japan and the Soviet Union may enter this market. Furthermore, I understand that China has just signed its first customer for a commercial launch.

Could you be more specific about the future activities of Japan, China, and the Soviet Union, and would you give us your assessment of when these countries are likely to enter the market and compete on a regular basis?

Do you expect Arianespace to seek a larger market share than 50%?

Answer. We believe that foreign launch providers have only limited capability to expand or accelerate production of launch vehicles for the world market in the short-term.

Arianespace has sized its production and launch facilities for an optimum rate of up to eight flights per year. While Arianespace has the capability of surging to ten launches per year for a short time, such a rate would not be sustainable without sizable investments in additional infrastructure.

The Soviet Union has indicated that it will compete for launches of commercial and foreign—including international organization—payloads. However, COCOM restrictions on technology transfer (the Coordinating Committee established by the NATO countries to coordinate exports of defense-related hardware or technology to the Soviet-bloc and China) are likely to prevent such launches.

China has agreed with the Swedish Space Corporation to conduct a technical study of a 1989 launch of a Swedish Mailstar satellite on a Chinese Long Mach vehicle. More recently, China has begun marketing its Long March vehicle to U.S. commercial customers. China is unlikely to compete in the world market on a regular basis until the 1990s.

Japan has been engaged in an active program to develop a launch vehicle based on domestic technology. However, its vehicle is unlikely to be ready to compete in the world market on a regular basis until the 1990s. Even at that time, Japanese launch operations will be severely constrained unless an alternate launch site is found as a result of limitations imposed by weather conditions and agreements with the Japanese fishing industry.

Question. According to your statement, the U.S. must advocate policies that foster a private sector space transportation alternative. What policies are necessary to ensure the viability of a U.S. ELV industry?

Answer. The primary policy necessary to ensure its viability is that the U.S. commercial ELV industry not find itself in competition with its own government. DOT, in its administration of the Commercial Space Launch Act, has established the necessary regulatory policies to encourage the development of a U.S. ELV industry. All that is now required is a clear policy signal from the U.S. Government that it will no longer compete with private industry for launch services.

Question. Do you believe that the fiscal year 1989 Shuttle pricing policy that was established last year is reasonable, or should it be reconsidered given the current circumstances?

Answer. The FY 1989 Shuttle Pricing Policy for foreign and Commercial Users, promulgated in July 1985, requires an annual review by NASA. The review will include an analysis of Shuttle cost experience and the anticipated future effectiveness of the pricing policy in implementing National Space Policy goals under changing market conditions. I am confident such an analysis will reflect current circumstances.

Question. What is your assessment of insurance capacity and rates for commercial ELV lauches, and what impact will this have on the commercial ELV industry?

Answer. Insurance capacity remains contrained, particularly for multiple payload launches, regardless of the launch system. We do not expect that U.S. commercial ELVs will be affected to any greater degree by increasing rates than any other launch systen. Indeed U.S. vehicles may fare better since they have supported with hundreds of missions reliability in excess of 95%.

Question. What companies, other than Transpace Carriers and Space Services, Inc., are actively trying to launch commercial payloads, and what growth do you anticipate in the number of industry participants?

Answer. General Dynamics has been actively marketing launches in the Atlas/Centaur class. Martin Marietta has been probing the market to comercialize the Titan.

Once the big domestic companies enter the market, we expect that smaller entrepreneurial firms will be encouraged by expansion of the market and will enter the competition.

Question. Where and when do you expect the next commercial ELV launch to take place, and whose ELV will be launched?

Do you expect any other commercial launches in the near future?

Answer. With the Shuttle grounded for an indefinite period, and a large backlog of military, civil, and commercial payloads building, there should be a considerable number of customers who will want to use U.S. commercial ELVs to gain access to space.

Senator GORTON We will now hear from Mr. Flora, Dr. Lovelace, Mr. Hood, and Mr. Hayden. You four have had a long afternoon waiting for us to get to you. It is the fate of the people who come last in these hearings. We are pleased to have you here.

We will start with you, Dr. Lovelace. In the case of each of you, your statements, written statements, will be included in the record and summaries will be appreciated.

STATEMENTS OF DR. ALAN LOVELACE, VICE PRESIDENT AND GENERAL MANAGER, GENERAL DYNAMICS CORP., SPACE SYSTEMS DIVISION; GARETH D. FLORA, VICE PRESIDENT, BUSINESS DEVELOPMENT, MARTIN MARIETTA DENVER AEROSPACE; ROBERT H. HOOD, JR., VICE PRESIDENT AND DEPUTY MANAGER, McDONNELL DOUGLAS ASTRONAUTICS CO.; AND DOUGLAS A. HEYDON, EXECUTIVE VICE PRESIDENT AND GENERAL MANAGER, ARIANESPACE, INC.

Dr. LOVELACE. Thank you, Mr. Chairman. We certainly will try to summarize this.

Subsequent to the *Challenger* accident, we in General Dynamics sat down to see what our assessment of the impact was and what we might be able as a company to contribute to the national recovery from this tragedy. We continue that study. We have completed the first cycles of the study. It tends to be a kind of "living study" which we try to keep up to date.

But without going into the details, the assumptions that we employed indicated to us that there is a severe shortfall of launch capability out through the middle 1990's. Certainly, as was indicated by prior witnesses, there are a number of payloads that cannot be accommodated which were formerly manifested on the shuttle, out through the 1989 time period. Those payloads are variously both military and commercial payloads.

We have come to the conclusion, as a result of our study and as a result of participating in the space transportation architecture study which was referred to earlier by Secretary Aldridge, that a mixed fleet capability is what is required in this country for the long haul. We have an immediate problem which we need to take care of. But we need to keep our eye on the longer view of things which in my perception will require both manned and either expendable or partially or fully recoverable unmanned launch vehicles.

We need a robust fleet. Because of the importance of space to this country, as indicated by the expenditures that we are making and our dependency on space operations, we cannot allow ourselves the luxury, if it is a luxury, of having single method of access to space.

We certainly, with the CELV, start—and with some of the existing expendable launch vehicles, the models of which were shown by Secretary Aldridge, have an existing capability. We need to go back, in my view, and revisit that, solve our short-term problem, but direct ourselves to a longer term solution.

I am happy to report that at least in part the Atlas family of vehicles offers such solutions, and we would be ready to provide those services. We did not get into this problem overnight and we are not going to get out of it overnight, and it is going to take us at best probably 30 months from a standing start, even though we are launching vehicles today, for new hardware. It is going to take us about 30 months to bring new hardware to the launch pad and start servicing this country's postponed requirements.

In a nutshell, Mr. Chairman, that is the essence of my statement and I will be glad now or later to try and address any questions.

[The statement follows:]

STATEMENT OF ALAN M. LOVELACE, VICE PRESIDENT AND GENERAL MANAGER, GENERAL DYNAMICS CORP., SPACE SYSTEMS DIVISION

Mr. Chairman, thank you for the opportunity afforded me today to appear before your distinguished subcommitte. The subject being addressed by this hearing, lost space launch capability, is of vital importance to us all because it ultimately affects United States ability to retain its preeminence in space.

The committee has requested our assessment of the ability of the United States commercial expendable launch vehicle industry to help meet our Nation's launch requirements. More specifically, the committee has requested information regarding the ability of General Dynamics to help reconstitute our civil and military space launch capability.

Subsequent to the *Challenger* accident, it became readily apparent to us there would be a national space launch capacity problem and it was our goal to offer constructive alternatives to help diminish this problem. Accordingly, the space systems division of General Dynamics undertook an independent study to determine the effect of the *Challenger* loss on our space launch capacity. The study to which I refer has been a "living study" in the sense that we have attempted to continually refine it as new information becomes available.

Our analysis assumes that the shuttle orbiter fleet will be grounded for either 12, 18, or 24 months. We assumed that a three orbiter fleet could fly at a rate of nine missions in the first year of renewed operation and fourteen missions per year thereafter.

The first significant result of our analysis indicates the shuttle launch capacity is more sensitive to the lowered shuttle flight rate than by the length of time the fleet is grounded. In other words it makes less difference that the shuttle is down twelve, eighteen or twenty-four months than the fact that the flight rate has been reduced by either fewer orbiters, longer turn-around time or lower launch rates.

The assumptions used in our study indicate that the 1986-1989 manifest dislocation is severe enough to suggest that the majority of missions which now likely to be flown by the shuttle will be limited to those that can only be flown on the shuttle. Our analysis indicates that a large percentage of the displaced DOD, science, or communication satellite missions that are not "shuttle-unique" cannot be accommodated in this timeframe. Finally, our study clearly identifies a substantial backlog of payloads in the shuttle manifest through the end of 1989 which are candidates for alternative launch vehicles.

The purpose of a diverse launch vehicle fleet approach is to make the space shuttle more available for national priority missions while providing reliable U.S. launch capacity for a broad user community. We believe that the shuttle manifest overflow will not subside. The shuttle program will most likely emphasize shuttle-unique payloads. Displaced users will either seek other launch capacity or reassess their projects all together.

Mr. Chairman, based on the results of our study, it is our firm belief that if the United States space program is to meet its current commitments, a diversified fleet of ELV's is absolutely essential. An acquisition strategy should address the long-term objectives of: (1) assuring our access to space; and (2) maintaining the industrial base needed to continue assured access beyond the near-term. I emphasize the word "continuing" because a "stop-gap" program to simply solve our immediate problem will not address the fundamental issue, which is to avoid disruption of our national launch capability in the future. I would also emphasize the word "diverse," because it is clear that the way to protect this nation against a recurrence of this situation is to have multiple capabilities where the country is not dependent on any one single system or manufacturer for its entire space launch capability. The national space trasportation system and its infrastructure must be robust.

The essence of this robust vehicle fleet is the diverse industrial base through which it is provided. It should consist of the shuttle and a variety of different ELV's matrixed across several manufacturers. NASA and DOD should manage the implementation of such a plan, coordinating the national capability with the demand and maintaining a practical surge capacity to assure access to space.

This plan should recognize the importance of complementary expendable launch vehicles as a supplement to the shuttle's unique capability. This plan must also uphold the Government's obligation to all manifested customers. The Government should employ a plan which would provide launch services to help alleviate the launch capabilities shortfall. This plan should also provide a method to acquire or guarantee the acquisition of expendable launch vehicles in such a manner that acquisition leads to the privatization of expendable launch vehicles.

In conjunction with our analysis of the shuttle manifest, we have assessed our own capability to help replace lost launch capability. I am pleased to report to the committee that the resources do exist in at least four major areas which would enable us, if called upon, to help meet the country's critical launch requirements. Those major areas are: (1) an existing inventory of launch vehicles, (2) an existing production line to manufacture additional launch vehicles, (3) an existing group of operational launch complexes from which to fly the missions, and (4) an existing team of experienced management, technical, and launch services personnel to staff a substantial program.

Regarding the first of these areas, existing launch vehicles, there are currently both Atlas and Atlas/Centaur's coming off the production line. Three Atlas/Centaur's are currently planned to launch Navy FLTSATCOM satellites. Two of those launches are scheduled for this year and one for next year. In addition, there remains one Atlas-H vehicle which is ready for launch and twelve Atlas-E's to be refurbished for launch from Vandenberg Air Force Base.

Secondly, in the area of production capability, we have the only existing operational production line to produce additional medium size launch vehicles in the country. It is our belief we have the current capacity to build three Atlas or Atlas/Centaur's in 1988, and five each in the years 1989 through 1992. Some additional investment in rate tooling and facilities could relieve manufacturing and launch operations choke points, and lead to production of three Atlas or Atlas/Centaur's in 1988, nine in 1989, and 25 per year beginning in 1990. The most critical spare asset for making that launch schedule, as well as the most time-sensitive, long-lead item we must procure, is Rocketdyne MA-5 engines. Our normal production leadtime to launch of an Atlas/Centaur is 30 months. We have begun early manufacturing planning in conjunction with Rocketdyne to assure this schedule will be attained. With additional capital investment, Atlas production rate is not a constraint (rates in excess of over 100 per year have been achieved in the past). Above 15 east coast launches per year, pad facilities become a constraint; however, west coast launch facilities may be utilized for some missions which provide growth to 25 launches per year.

Future production of the Centaur upper stage vehicle can also be accelerated by the addition of more facilities, thus expediting production of Titan/Centaur, Atlas/Centaur as well as the shuttle/Centaur. Our total current production and launch capacity for Centaur is two in 1986, four in 1987, three in 1988 and five from 1989 on. Additional tooling would increase our launch availability from three to five in 1988, five to ten in 1989 and five to sixteen beyond 1990.

The third area where substantial existing assets can be drawn upon is in launch sites. Launch facilities are in existence which will support increased ELV activities, and other facilities exist which could be reactivated to meet all the necessary requirements in accommodating the displaced shuttle payloads. Three existing launch sites, two at Vandenberg Air Force Base and one at Cape Canaveral, currently support Atlas and Atlas/Centaur launches. Two other complexes at the cape could be readily reactivated. These are launch complex 36A and launch complex 13, both of which would support Atlas and Atlas-G/Centaur. Complez 36A is currently used for shuttle/Centaur testing, but this operation could be moved to another location. Launch complex 13 could be refurbished and reactivated for Atlas and/or Atlas-G/Centaur launches. One launch pad at Vandenberg Air Force Base is scheduled through the early 1990's to accommodate the remaining twelve Atlas-E launches. The other launch pad Vandenberg Air Force Base has only one remaining mission scheduled and could be available for additional polar orbital missions for DOD and civilian launches. Both pads could also be utilized for SDI testing.

The fourth and final resource which we have on hand today is perhaps the most important of all, and that is the existence ofthe team of dedicated and experienced management, manufacturing and technical personnel who have made the Atlas family of launch vehicles one of the most successful programs in the world for over a quarter of a century. To date 486 Atlas's have flown. These missions have included manned, scientific, planetary, meteorological, NAVSTAR GPS and commercial communications satellites.

We believe the space shuttle is a magnificent flying machine. We regret, as do all Americans, the *Challenger* tragedy and the loss of the seven brave and dedicated crew members. We do, however, trust that the space shuttle will soon fly again and be a great source of national pride. We believe the shuttle capacity should be replenished. The shuttle represents the Nation's access to a future in space. The next generation of space exploration, the space station, SDI and the programs which are to follow can only be made possible through the existence of a practical shuttle fleet to provide manned access to near-earth space and someday to the planets.

We are here to convey that ELV capability exists to alleviate the portion of shuttle overflow—both near-term and long-term—which is not shuttle-unique in nature. The Atlas and Atlas/Centaur family of vehicles can accommodate the majority of communications satellites at significant launch rates to make the space shuttle available for national priority program. With modest improvements the Atlas/Centaur can provide launch services for additional payloads which previously had only shuttle or Ariane from which to choose.

Atlas/Centaur, which has been America's "workhorse" for launching communications satellites, offers the possibility of a synergistic relationship between DOD expendable launch vehicles and commercial expendable launch vehicles. Because Atlas/Centaur is so well suited for a broad range of commercial payloads and possesses the ability to launch priority DOD payloads such as GPS, it may flexibly supplement the shuttle's manifest.

In that regard, Mr. Chairman, I would recommend that we reconstitute the Nation's space launch capabilities to ensure a robust system consisting of the shuttle and selected expendable launch vehicles with a corresponding industrial base in order to support our country's needs. The overall objectives of our space program depend upon our ability to conduct space launches.

Thank you for affording me this opportunity to express my views and I will be happy to answer any questions this committee may wish to pose in this regard.

Senator GORTON. Mr. Flora.

Mr. FLORA. Thank you, Mr. Chairman and members of the subcommittee. Martin Marietta welcomes this opportunity to come address you today and talk to you primarily about the Titan family of launch vehicles.

In order to expedite, I will really just highlight very briefly the testimony that I have submitted to you. Actually, I must confess that Martin Marietta and its teammates are really part of the mixed fleet right now.

As Secretary Aldridge testified, we have three primary Titan systems that are in being, either in production, launch or development phases, right now. Just to review briefly, the first is the CELV which is the new complementary expendable launch vehicle which will complement shuttle in terms of performance and that it is a buy of 10, on a fixed-price contract, with a first launch in October 1988.

I might mention that we have a very broad-based team with the CELV. It is really an omnibus team. In fact, McDonnell Douglas is our payload faring contractor. General Dynamics is our Centaur contractor. Aerojet General is our liquid rocket engine contractor. Chemical Systems Division of UTC is our solid rocket motor contractor. And General Motors Delco is our guidance contractor. So, it is a wide-based infrastructure industry team.

The second program is the Titan II refurbishment program that Secretary Aldridge spoke about. We are under contract now for eight of those with a follow-on of five to be launched at a rate of two per year from Vandenberg Air Force Base, low Earth polar orbit missions. Now, that is a very viable program. Again, we have teammates at McDonnell Douglas and Aerojet General and Delco, providing the various subsystems for us.

Last, the third system we are currently involved in is the current 34D which is the Air Force's operational system today. There are seven of those left. They are currently scheduled to launch DOD missions out through early 1988.

It is that 34D that we have examined in detail to do a dual launch capability of any and all satellites that would fit the PAM-D or PAM-D2 class. It is also that vehicle that we bid in the Intelsat competition in 1983.

We see the Titan 34D and the return to manufacturing of that vehicle as the most likely candidate for Martin Marietta in terms of a commercial launch vehicle. In that vein, we have been asked by the National Security Council Senior Interagency, the SIG Space as we call it, "if the Government were to cease launching commercial and foreign satellites would Martin Marietta compete for those launches with the Titan family of vehicles?"

Our answer on that was yes. Clearly, our thinking is, should that policy be made, the Titan 34D with its dual launch capability is a very competitive, very reliable and flexible vehicle. It could meet those needs.

We have looked at build and launch capabilities with our DOD work and the commercial work. There is really no problem. We are talking about manufacturing rates of up to 14 a year. We have four launch pads in existence and operational today, which could handle launches of 16 to 20 per year. So, there is really no problem in terms of capacity.

With that, I will conclude my remarks by thanking you for letting us be here, and I will await your questions.

[The statement follows:]

STATMENT OF GARETH D. FLORA, VICE PRESIDENT, MARTIN MARIETTA DENVER AEROSPACE

Mr. Chairman and members of the subcommittee: Martin Marietta welcomes the opportunity to come before you and discuss the Titan expendable launch vehicle family. I have divided my opening comments into three parts. First I will briefly discuss the Titan history; secondly I will discuss the current Titan programs. And lastly I would like to comment briefly on the viability of U.S. commercial expendable launch vehicle industry.

In the early 1960s Martin Marietta developed a national space launch vehicle for the Air Force. The Titan III launch vehicle development effort evolved from our very successful and reliable Titan I and Titan II ICBM programs. We successfully launched 114 Titan IIIs from 1966 to 1974. In 1975 we first flew the Titan 34B and in 1982 launched the first Titan 34D. Over the last twenty years Titan expendable launch vehicles have been successfully operationally launched 141 times. This includes twelve successful launches for the manned Gemini program.

Perhaps it is this sustained reliability of which we are most proud. Titan is the most reliable expendable launch vehicle in existence, with a better than 97% success rate. We have placed a wide array of national security satellites into various orbits and have launched planetary probes on missions to explore the solar system. In short, the Titan is a proven launch vehicle, incorporating modern technology, with unparalleled flexibility and reliability.

With regard to our present status, I am pleased to report that we are currently in various stages of production and development on three Titan space launch systems. Our major development effort is the Titan complementary expendable launch vehicle (CELV). Last year, after a sustained and challenging industrial competition, the Air Force awarded Martin Marietta and its subcontractor team a contract for the development and production of a complementary expendable launch vehicle for launching shuttle equivalent payloads. This procurement was driven by the Nation's requirement for assured access to space and the Titan CELV is the vehicle that provides it. The Titan CELV team is broadly based. Martin Marietta is the prime contractor and principal subcontractors include McDonnell Douglas and General Dynamics in addition to united technologies, GM-Delco systems and aerojet tech systems. The Titan CELV can place a 10,000 pound payload in geosynchronous orbit or a 32,000 pound payload in low earth polar orbit. Our fixed price contract calls for the production of 10 CELVS through 1993 with the first launch scheduled for October 1988. The Air Force as you may know, has discussed the possibility of an additional CELV procurement. Accordingly, we have initiated efforts to increase CELV production and launch capabilities to be responsive to the Nation's critical launch vehicle shortfall.

Next, let me mention the Titan II space launch vehicle. We are under contract to the Air Force to refurbish Government-owned Titan II ICBMs for use as space launch vehicles. In this effort we use the guidance systems, payload fairing, attitude control system and other critical elements of the proven Titan 34D to assure that the refurbished Titan II space launch vehicle meets demanding performance and reliability standards. The result is a low cost ELV built largely from existing U.S. Government assets. A Titan II space launch vehicle can place payloads weighing up to 4,200 pounds into a low earth polar orbit. Martin Marietta's fixed price contract calls for eight vehicles with an option for five additional vehicles to be refurbished from the government inventory of 56 Titan II ICBMS. The first Titan II space launch vehicle scheduled launch is in April 1988. As with the CELV, we are providing planning and performance data to the Air Force regarding enhancements of the baseline program.

Thirdly I would like to discuss the Titan 34D—the Air Force's current operational Titan space launch vehicle. Titan 34D can place 4200 lbs in geosynchronous orbit. It also is capable of putting payloads ranging up to 33,600 pounds in low earth orbit depending on the inclination. There are currently seven Titan 34D and one Titan 34B in Air Force inventory awaiting launch from either east or west coast facilities. The Titan 34D now under construction in Denver is the 468th Titan to be manufactured.

The Titan 34D provides flexibility to the Nation for payloads classed between Titan CELV, and Titan II space launch vehicle. It provides a potential Government launch alternative for the TDRS and has the potential to launch mixed Government payloads such as Skynet and DSCS III. The Titan 34D is a viable competitor to Ariane 3 and 4 launch vehicles and can launch dual PAM D and PAM DII class satellites. The Titan 34D provides the most proven and realistic solution to the shuttle manifesting backlog the Nation now faces for both commercial and Government payloads.

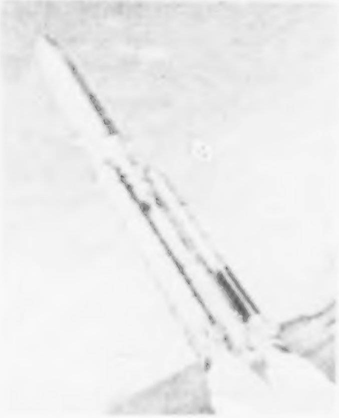
In that vein, we have been asked by the National Security Council, senior interagency group (SPACE) "If the Government were to cease launching commercial and foreign satellites, would Martin Marietta compete for those launches with the Titan family of launch vehicles?" Our answer is yes. The Commercial Space Launch Act of 1984 legislates that the United States encourage the private sector to develop a viable and competitive commercial space launch industry. The Titan launch vehicle with its proven reliability and flexibility, coupled with the substantial projected DOD production and launch plans, can provide the long-term viability and competitiveness essential for a U.S. commercial launch vehicle system. Martin Marietta accepts the challenge of competing to keep that pre-eminent role for America based on the policy guidance and encouragement contained in President Reagan's national space policy directives.

Under all envisioned projections, the Titan manufacturing and launch elements have excess capacity. For example; a recent assesment for the Air Force of a mix of five CELVS, three Titan 34DS, plus six Titan IIs at a total rate of 14 per year presented no difficulties and did not approach our historical production of 20 Titan IIs a year. Moreover, the Nation has already built the facilities to launch Titans at a rate in excess of that at which we can build them. Four operational launch sites exist and are designed for Titan launches on the east and west coasts. This provides the Nation the capability to launch Titans at a rate in excess of 16 to 20 per year.

In sum, we are very proud of the Titan heritage and the team that builds and launches them. The Titan, and its existing, operational, production and launch facilities are a national asset. As I pointed out in the earlier part of my statement, the Titan launch vehicle has been in production for almost 30 years. Each succeeding generation has incorporated technological improvements. The Titan family of contractors offer demonstrated stability and an established, ongoing business well into the 1990s. The Titan family of launch vehicles exists now. It meets the broad spectrum of user requirements and is a viable, proven candidate for a U.S. commercial launch system.

Thank you, I will be happy to respond to your questions.

COMPLEMENTARY EXPENDABLE LAUNCH VEHICLE (CELV)



- UNDER CONTRACT TO DEVELOP AND BUILD TEN CELVs
- SHUTTLE EQUIVALENT PAYLOAD
- MULTIPLE PAYLOAD CAPABILITY
- DISCUSSING ADDITIONAL PROCUREMENT
- INITIAL LAUNCH CAPABILITY: OCTOBER 1988
- MAXIMUM PAYLOAD SIZE: 15' DIAMETER x 40' LENGTH
- GEOSYNCHRONOUS ORBIT: 10,000 LB
- LOW EARTH POLAR ORBIT: 32,000 LB

TITAN II

- UNDER CONTRACT FOR REFURBISHMENT OF EIGHT VEHICLES WITH AN OPTION FOR FIVE ADDITIONAL VEHICLES
- SMALL SPACECRAFT LAUNCH CAPABILITY TO LOW EARTH ORBIT
- DISCUSSING ADDITIONAL PROCUREMENT
- INITIAL LAUNCH CAPABILITY: APRIL 1988
- MAXIMUM PAYLOAD SIZE: 9.3' DIAMETER X 25' LENGTH
- LOW EARTH POLAR ORBIT: 4,200 LB

TITAN 34D

- SEVEN TITAN 34Ds IN AIR FORCE INVENTORY
- FLEXIBLE ALTERNATIVE FOR GOVERNMENT PAYLOADS
- MULTIPLE SPACECRAFT CAPABILITY
- COMMERCIAL LAUNCH VEHICLE ALTERNATIVE
- PAYLOAD SIZE: 9.3' DIAMETER x 47.1' LENGTH
- GEOSYNCHRONOUS ORBIT: 4,200 LB
- LOW EARTH POLAR ORBIT: 27,500 LB

LAUNCH COMPLEXES

TWO TITAN LAUNCH COMPLEXES ON EAST COAST -- TWO ON WEST COAST

- FOUR TITAN LAUNCH COMPLEXES EXIST -- THREE ACTIVE AND ONE UNDER MODIFICATION
- LAUNCH CAPABILITY EXCEEDS ANY PLANNED REQUIREMENTS
- MINOR IMPACTS FOR COMMERCIAL TITAN

MANUFACTURING CAPABILITY

HISTORICAL BUILD RATE FOR TITAN II ICBM = 20 / YEAR

- CAPITAL INVESTMENT FOR TITAN PRODUCTION AND LAUNCH CAPABILITY LONG ESTABLISHED
- TITAN PRODUCTION RATE CONSIDERABLY LESS THAN CAPACITY FOR YEARS
- PLANNED USAGE -- CURRENT CELV AND TITAN II SLV CONTRACTS -- ONLY REQUIRES ONE-THIRD OF PRODUCTION CAPACITY
- EASILY ACCOMMODATE TITAN BUILD RATE = 14 / YEAR
- COST OF HIGHER PRODUCTION RATES MODEST: LIMITED TO ADDITIONAL RATE TOOLING, TEST EQUIPMENT AND HANDLING EQUIPMENT

[The following information was subsequently received for the record:]

Questions of Senator Gorton and the Answers

Question. You represent an ELV manufacturer that could potentially benefit if there was less shuttle capacity.

Given that assumption, should the Challenger be replaced?

Answer. The Air Force and NASA have stated that the nation needs both additional expendable launch vehicles and another orbiter to meet the overall national space launch demand. In industry we are not cognizant of the full spectrum of national security, exploration and civil space launch requirements. Nonetheless, we support the mixed fleet approach outlined by the Air Force and NASA for additional expendable launch vehicles and an additional orbiter.

Question. Within the Senior Interagency Group (SIG) space discussion, there is talk of precluding the shuttle from launching commercial communications satellites.

Does this make sense given the current circumstances and would such a policy guarantee the vialibity of a U.S. commercial ELV industry?

Answer. We understand the shuttle may have difficulty fulfilling commitments to launch commercial payloads particularly given that the DOD has the priority to bump those payloads. Accordingly, if the government decides not to launch commercial and foreign payloads on the shuttle, we would complete to launch these satellites. As to the second part of the question, we believe that the health of that industry can best be assured with the kinds of encouragement the government has recently displayed and by market forces. The market is not large, but three launch vehicle manufacturers would probably compete for available payloads. All would probably not survive, but that is competition. In an analogous aerospace industry-because of market pressures-not all American widebody aircraft companies are still building widebody aircraft.

Question. Given the targeted market share of Arianespace (50%) and the ELV launch market assessments, is your company willing to make the necessary investments to pursue the remaining 50% of the commercial launch market?

If not, what do you need to enter this market?

Answer. Entering the commercial launch vehicle market must make business sense. We must have the support and encouragement of the U.S. government since we need access to U.S. facilities and range personnel. The President's space policy and the Commercial Space Launch Act give us confidence that the nation supports the development of an American commercial space launch business.

Following a government decision to not launch commercial and foreign payloads, we would enter the market. We have an actice ELV production base and could move rapidly. The investment to develop a commercial Titan would be modest and we could probably launch a first commercial payload in early 1989. Moreover, we believe that an American commercial ELV base can and should be pursued without government subsidy. Competing with Ariane would be a challenge, but we believe we can meet that challenge successfully.

Question. How many launches per year would your Titan 34D system require to be viable?

Answer. That answer depends on a number of variables such as the number of satellites, production and launch costs, and the competitive marketplace. Our initial estimates, however, suggest one to three commercial Titan launches per year would put us in the competitive range.

Question. Do any of your ELVs have the capability to efficiently span both commercial and DOD mission profiles, and if so, in what ways?

Answer. The Titan 34D can efficiently span commercial and DOD mission profiles. The Titan 34D is a proven workhorse for national security payloads and is our initial choice for the commercial launch vehicle. The Titan 34D offers the ability to carry two payloads at once. An additional advantage of the Titan 34D is that is has been integrated with both IUS and Transtage. This would allow NASA or DOD payloads already integrated with the IUS on the shuttle to fly on the Titan with minimum modification. We believe that the ability to mix government and commercial payloads on one flight may have substantial benefits for both participants in terms of shared risk and reduced costs. Moreover, we are currently operating at substantially less than full capacity and can accept additional business with no negative impact on government work.

Question. I understand that if the global positioning system (GPS) satellites are off-loaded from the shuttle, a considerable payload capacity on the shuttle would become available. What options can you offer to efficiently launch these GPS satellites, and when could these launch options be available?

Answer. We can offer four options: launching GPS satellites, one at a time using the Titan II space launch vehicles or the Titan 34B; launching GPS satellites one or two at a time using Titan 34Ds. The Titan 34D can comfortably carry two GPS satellites or a mix of one GPS satellite and a commercial satellite or other government payload. Finally, two and possibly three GPS satellites could be launched using the Titan CELV. Depending on the requirements of the Air Force RFP, it is thought that all the above configurations could meet the prescribed launch date.

Question. I am sure you can make the case that ELVs should be procured for DOD and NASA. Given the current budget environment, are there reasons why more than one ELV line should be activated to support our national space launch requirements?

Answer. Competition should determine how many commercial ELV lines could be viable. Competition for commercial payloads would benefit the government. Production of commercial launch vehicles would result in a lower cost to fly NASA and DOD payloads on expendable launch vehicles because of production efficiencies.

Question. What ELV procurement strategies might the government employ that would also minimize the budgetary burden to the taxpayer?

Answer. The budgetary burden on the taxpayer is minimized by open competition for services to the government. NASA and the DOD benefit by having competitive selection for ELVs. Competitive pressures assure both the lowest possible price and greatest technical efficiency. It also provides that appropriate research and development investment are made. If the nation decides to develop a commercial space launch industry, the industry can be developed and sustained without government subsidy. We do not believe that it is in the nation's best interest to pursue subsidized ELV development.

Senator GORTON. Mr. Hood.

Mr. HOOD. Thank you, Mr. Chairman. I also will be brief, but I would first like to say that it is our position that in order to assure our continued access to space and to have a healthy, robust space transportation industry, that a diversified fleet of ELV's is mandatory.

The issue is no longer the question of when, but what is the most appropriate way to do it and what is the appropriate mix. There would appear to be two approaches, one to turnall commercial missions over to the U.S. commercial launch vehicle industry, which would develop the handling requirements, and the second would be a Government-supported mixed fleet consisting of both shuttles and ELV's. In this approach the commercial customer would pay the same price for either launch vehicle.

I want to highlight just one or two things. Since we have considerable experience in the commercial launch vehicle ventures over a number of years, we are here to share some of our experiences, thoughts, concerns and recommendations with you. You will recall that back in 1973 we in fact did upgrade the Delta launch vehicles so that RCA would have the excess capability of putting a 24-channel TV spacecraft into orbit to replace a 12-channel spacecraft.

We did that. We spent our own money in doing that. We expected it would take us nine missions to recover it. It took us 18 missions and 10 years to recover, but that was a successful commercial venture.

Unfortunately, I think that is the only one. Our experience, of course, in 1976, we entered into an agreement with NASA to provide a company-funded upper stage, and you know that as PAM. A couple years later we developed the PAM-D2 because the communications satellite business required that additional capability.

Unfortunately, to date, we have only sold 71 of these vehicles. We have launched about half of them. And I would like to report that it has been a financial success, only it has not. With over $150 million invested in that, we are still far from the break-even point, and one of the reasons for that, by the way, is we did have a failure in 1983 and one has to be ready to investigate and improve and make whatever necessary changes to the launch vehicle or the upper stage are required when you do have a failure.

Now, the problem is that that brings me to one of my major concerns, and that is that upper-stage investments that I mentioned were made in good faith with the understanding that the shuttle would be available for commercial missions. And that was one of those clear signal policies that we talk about. And now, we understand that there is going to be a policy shift that would deny such availability and eliminate our ability to recover our significant investment.

Policy fluctuations such as this certainly are a red flag to future investors contemplating a commercial space venture. I would just like to point out one other thing we have examined, the question of commercializing Delta a number of times over the past several years.

Based on our competitive experience since 1978 in the world market, we have not done that. The reasons we have not done it and the risks are this: large production start-up cost—right now we would be looking at something like $100 million to contract for long lead time items, plus continued investment in upgrading our product to remain competitive, and reserves, as I said earlier, for failures and adversity.

And one of the big issues that we have not even heard discussed here today is the unavailability of insurance, or extremely high insurance costs and foreign competition. We have talked to about at least four countries involved in that today, and of course the shift of U.S. Government policy.

I think, Mr. Chairman, that there are several ways we can go about this, but I have not heard one here today that I would be willing to go to my management and suggest we invest in, unless the Government steps up and orders some of these vehicles first and gives me the production base as Mr. Aldridge indicated earlier, from which I could then make some commercial plans and possibly enter the commercial market.

Thank you very much.

[The statement follows:]

STATEMENT OF ROBERT H. HOOD, JR., VICE PRESIDENT AND DEPUTY GENERAL MANAGER, MCDONNELL DOUGLAS ASTRONAUTICS CO.

Mr. Chairman, members of the committee: Thank you for inviting me to address an issue which has been brought to focus because of the recent shuttle tragedy. i.e., reconstitution of our space launch capability. Having been on the leading edge of space launch vehicle commercialization, we appreciate the opportunity to share some of our experiences and to discuss our concerns and recommendations for a healthy national space transportation industry. MDAC has the desire and ability to contribute to the reconstitution of the Nations space launch capability.

COMMERCIAL SPACE BACKGROUND

MDAC frist ventured into the space commercial world in 1973 by uprating the expendable Delta vehicle thru the use of larger strap-on rocket motors. This was accomplished thru the cooperation of NASA, in conjunction with the initial user, RCA. MDAC developed these improvements on company funds at its own risk and launched the first uprated vehicle in 1975. This uprating allowed RCA to place a 24 TV channel spacecraft into orbit in place of the 12 channel spacecraft allowed by the earlier Delta capability. Twice the planned number of missions were required to recover the development dollars invested (18 missions) but this was finally accomplished in 1983, ten years later. This may be the only financially successful commercially developed launch vehicle in the United States history. I base this on our subsequent experience in the highly competitive world launch market as you will see later.

Our next space commercialization venture occurred in 1976 when MDAC entered into an agreement with NASA to provide a company funded upper stage which would propel satellites, primarily communication spacecraft, to geosynchronous transfer and other high orbits out of the shuttle. This stage was also suitable to perform the same function when used as an upper stage on Delta thereby increasing its payload capability and expanding the market for Delta. The agreement made it possible for NASA to divert funds to the shuttle program which would have been utilized for upper stage development. NASA agreed in return not to develop a competing upper state. MDAC called the stage the PAM-D for Payload Assist Module Delta Class and plunged forward into the competitive world market. 12 PAMS were launched on Delta from November 1980 thru 1984. The STS became operational in 1982 with the two PAM-DS launching communications spacecraft on its first operational flight.

One of the facts we've learned the hard way is that the communication satellite business is very dynamic and growth oriented, leading to consistently higher demands from satellites. This reflects in ever increasing demands for greater launch capability. In replying to this demand MDAC invested heavily in a growth version of the PAM-D called the PAM-DII. First launch of the PAM-DII was in late 1985.

MDAC, to date has sold a total of 71 launches with the PAM family, about evenly split between PAM-D and PAM-DII. About 1/2 of those sold have been launched to date. I would like to report that our commercial PAM ventures have been financially successful.

Unfortunately this has not been the case. With over $150M invested in the PAM series we are still far from a breakeven point. A significant part of this loss position is attributable to the analysis and recovery from PAM failures in 1983. Our loss today is more than $80M considering the cost of money and will remain at that level unless additional commercial shuttle launches are approved.

CONCERNS

This brings about a major concern relative to emerging space transportation policy. The upper stage investments previously mentioned were made in good faith with the understanding that the shuttle would be available for commercial missions. We are understandably concerned about a policy shift that would deny such availability and eliminate the ability to recover our significant investments. Policy fluctuations such as this certainly are a "red flag" to future investors contemplating a commercial space venture.

MDAC also has concerns about the reconstitution of the Nation's civil space launch capability. The department of defense, based on recent Senate testimony, considers the need mandatory for a mixed fleet of shuttles and ELVS. This need also appears to be mandatory on the civil space side. How does the U.S. acquire this capability in the most expeditious manner with the highest probability of success?

MIXED FLEET POLICY

Two approaches appear to be foremost in this consideration. One is to turn all commercial missions over to the U.S. commercial launch vehicle industry which would emerge to handle the requirements.

The second, a Government supported mixed fleet, consisting of both shuttles and ELVS, would perform all missions. In this approach the commercial customer would pay the same price for either launch vehicle.

MDAC has examined the question of commercializing Delta a number of times over the past several years. Based on competitive experience since 1978 in the world launch market, we have learned that a commercial organization cannot compete with Government sponsored launch vehicles. The commercial risks are far greater than can be accepted. These risks are:

Large production start-up costs.

Continuing uprating investments to remain competitive.

Reserves for failures and adversity.

Unavailable insurance or extremely high insurance costs.

Foreign competitors flexibility on pricing/financing.

U.S. Government policy shifts.

On the other hand, a Government sponsored mixed fleet approach can easily be put in place by extending current ELV contracts. There was a period in the early 1980's where NASA operated a mixed fleet in a very similar manner, so we have been there before. This approach is the only way that the U.S. can be positive that a diversified ELV industrial base will remain in the United States and that a complementary launch capability to the shuttle will be available to assure future access to space under any adversity.

SUMMARY

In summary, Mr. Chairman, I have tried to present the unique experience that MDAC has undergone in international market competition over a period of 10 years. My report is not a positive one but is based on the realism of the marketplace. The conclusion is clear. The "easy" route is to assume that American private industry will step in and provide a solution without Government involvement and funding. In a normal marketplace American know how and Yankee ingenuity would prevail. However, we are not addressing a normal marketplace. We are facing national interest where foreign governments are determined to maintain and expand their space activities in the world arena.

The Chinese are actively promoting their launch vehicle capabilities in the U.S. today and the Russians have already proposed their proton vehicle to international organizations in which they are a member.

The Japanese are expected to enter the marketplace with their own launch vehicles in the near future. The europeans have captured 50% of the current international market and have the capability to launch all of the worlds commercial spacecraft with the introduction of their second launch pad in French Guiana. I'm afraid that the U.S. will discover two or three years from now that U.S. private industry cannot compete and that the world's commercial launch needs are being met by Government sponsored organizations outside the U.S.

The world is watching our democratic system progress thru a very critical self examination. Our national prestige is taking a beating on the international scene. MDAC maintains that we should "bite the bullet" now and assure that the U.S. will remain the leader in space transportation by providing a Government supported mixed fleet system, a system that provides an unparalleled assurance of successful launch at a reasonable cost.

Thank you for the opportunity to participate in this decision making process.

[The following information was subsequently received for the record:]

QUESTIONS OF SENATOR GORTON AND THE ANSWERS

Question. You represent an ELV manufacturer that could potentially benefit if there was less Shuttle capacity. Given that assumption, should the Challenger be replaced?

Answer. Yes, the lost shuttle orbiter should be replaced. The advent of the Space Station as part of a total space infrastructure will in itself require a robust orbiter fleet for support.

Question. Within the Senior Interagency Group (SIG) Space discussion, there is talk of precluding the Shuttle form launching commercial communications satellites. Does this make sense given the current circumstances, and would such a policy guarantee the viability of a U.S. commercial ELV industry?

Answer. The proposed (SIG) Space change in policy to preclude the Shuttle from flying commercial payloads does not make sense and will do absolutely nothing to guarantee the reliability of a U.S. Commercial ELV industry. Four things are needed to support a commercial ELV industry:

(1) Clear and consistent sustaining government policy because none of us can afford to compete with the government.

(2) The use of government launch facilities on an added cost basis.

(3) Government supported business base from which an additional number of vehicles could be sold on a commercial basis on an added cost basis.

(4) Government supported reserves for failure investigation, insurance and other adversities.

Question Given the target market share of Arianespace (50%) and the ELV launch market assessments, is your company willing to make the necessary investment to pursue the remaining 50% of the commercial launch market? If not, what do you need to enter this market?

Answer. McDonnell Douglas would not be willing to make an investment for the remaining 50% of the ELV market without a guarantee from the government for 4-6 launches per year. We would still find ourselves competing with the Japanese, Chinese and others on a government subsidized basis.

Question. How many launches per year would your Delta system require to be viable?

Answer. Four to six launches per year would give us a viable Delta program.

Question Do any of your ELVs have the capability to efficiently span both commercial and DOD mission profiles, and if so, in what ways?

Answer. Delta could launch the DOD GPS program as well as the smaller class commercial communication satellites. Delta's payload capability with minimum modification is 3,300 lbs. to geosynchronous transfer orbit.

Question. I understand that if the Global Positioning System (GPS) satellites are off-loaded from the Shuttle, a considerable payload capacity on the Shuttle would become available. What options can McDonnell Douglas offer to efficiently launch these GPS satellites, and when could these launch options be available?

Answer. MDAC could use the Delta launch vehicle to launch the GPS satellite about 30 months after approved start.

Question. I am sure that you can make the case that ELVs should be procured for DOD and NASA. Given the current budget environment, are there reasons why more than one ELV line should be activated to support our national space launch requirements?

Answer. I believe that for economic as well as security purposes that at least two different expendable launch vehicles should be in production, one medium class and one heavy class.

Question. What ELV procurement strategies might the government employ that would also minimize the budgetary burden to the taxpayer?

Answer. In my mind the only cost saving mechanism for the government to reinstate our expendable launch vehicle capability would be to enter into a multi-year contract allowing each contractor to take maximum advantage of the economies of scale.

Senator GORTON. Thank you.

Mr. Heydon.

Mr. HEYDON. Well, after all that has been said about Ariane today, I am beginning to feel like I should have my black hat on.

Senator GORTON. Well, at least we got two laughs. You get the final word.

Mr. HEYDON. The last liar wins, I suppose.

I would like to apologize for our chairman, who would have liked very much to be here himself. As you know, he was here in November. And I will try to do my best to fill in for him.

You have asked us to address the question of how much Arianespace can increase its capacity, and how much are we likely to do so. I think the basic answer to that is really quite simple, and it is in what I would characterize as a classic good news-bad news kind of answer, and I will explain that as we go through the next few minutes.

I think it needs to be put in the context of the overall shortage, the issue of the shortage we are looking at today. First of all, satellite launching, the business that we are in, is inherently a low-volume business, even though the estimates are very widely ranging as has been alluded to earlier. The absolute numbers are low.

For our planning purposes in recent years, we have been using a range of 20 to 25 launches a year worldwide. On that basis, and with the objective of maintaining the share of about half of the commercial launch market which we are near attaining, and considering the number of shared and dedicated launches that we have on our schedule, we have consistently been planning on 6 to 8 launches a year to launch 10 to 12 satellites, since we do launch about half of our vehicles in a shared launch configuration.

Even to achieve this kind of rate increase has required a significant growth in our capability. We have added ELA-2, the second launch complex, which just went into operation. It will allow us the opportunity to increase our launch rate from the current maximum of 6 to a realistic maximum of 10, but that is not the limiting factor.

I would like to clarify that because there has been a lot of misunderstanding on the subject, since our new launch pad does not really give us two launch pads except for a short period of time because pad one will be phased out in early 1988 when we initiate exclusive use of Ariane 4's, which requires the use of the second pad.

At the time of the *Challenger* accident we had unsold, on our manifest through 1988, something on the order of seven or eight launch opportunities or slots, that is, opportunities to launch seven or eight payloads. A month later, at the end of February when Mr. d'Allest held a press conference, he announced that at that time we had about four of those opportunities left and that we could and would increase the launch rate to our maximum present capability, from six to about eight.

This capability is limited by our manufacturing and personnel limitations, not by the launch rate, and would effectively add one launch per year to the seven we had been planning, and if we assume they were both double launches it would have added four launch slots or opportunities. These, added to the four that existed at the time Mr. d'Allest made his statement, that said we could pick up as many as eight satellites or payloads through the end of 1988.

It should be pointed out that there is a difference between a launch and a launch opportunity, since we do launch in a double configuration about half the time. We also have the situation of large satellites such as the Intelsat VI, two of which we are contracted to launch, taking up a full launch vehicle.

We are looking at the possibility of further increases, up to as many as 10, but it would require significant increases of people, and on a more permanent basis, facilities. At the very least, it would take 2½ to 3 years to see any output at the other end of the pipe, with an immediate increase in personnel. We could go to a three-shift operation. We could add some additional people in that sense. To permanently increase the rate by adding more tooling and facilities would take even longer, and we would not see the output of that for a minimum of 3, and more likely 4, years. It is very consistent with what Dr. Lovelace said a few moments ago. It is not generally realized how long lead a business this is we are in, but the bits and pieces that make up these vehicles are difficult and complex and take a long time to build.

Either of these approaches is costly, whether it is adding manpower and going to three shifts for a temporary increase in capacity, or adding tooling and facilities for a permanent increase in capacity, and we do not plan to undertake them because we don't have the clear indications that the demand is there on a firm, long-term basis.

Ms. Johnson said something in her comments which struck a responsive chord with me. Capacity is a function of the demand, and it really is. We are not going to add the capacity unless the demand is firmly there.

Our past assessments and our market aspirations which very realistically are no more than half—we are political realists and recognize that attempting to corner the market would be a politically disastrous thing for us to do worldwide, and is also unachievable—so we have had a consistent plan of six to eight launches a year, and our recent schedule of seven a year has been consistent both with that projection, and it has allowed us the slight cushion that we need to provide for some contingencies such as the failure we had last September.

As Bob (Hood) said a moment ago, failures have to be provided for and recovered for, and we are undergoing the results of one of those right now.

The other advantage of our production and launch rate of about seven a year has been that it has allowed us to use our capacity and facilities on a very efficient basis, and this is one of the reasons that our costs have been low and we have been able to be competitive. Contrary to all of the assertions that are made in this regard, we are not subsidized, and if people try to talk themselves into believing that we are, it is for some other purpose.

What is required for us to go to more than eight? Well, I think I have alluded to that. A certain increase in demand over what we see today and what our projections show, and we do not see that certainty of demand.

If we look back just 3 months on our manifest, we had a great many holes in late 1988 and everything beyond was totally empty. Neither the demand nor the competitive environment at that time gave us any reason to increase capacity, and the uncertainties in that environment have caused us continually to reassess our production and launch rates.

So this all leads to one conclusion, that neither in the past or today do we see clear indications that the manpower and plant capacity are either required or justified. We are not prepared to make the investment on the basis of today's uncertain market and competitive conditions.

I will summarize by saying that we can increase from our recent level of seven to eight launches a year, and we plan to do that beginning in 1987. We will be launching eight a year from 1987 on until we see the near term demand diminish. We can temporarily increase that to 10 by adding extra shifts and personnel. A permanent increase to a rate of 10 is feasible with a large capital investment, but it would not affect the launch rate before 1989 or 1990, and today's conditions simply do not provide a sound business basis for the investment required to achieve a significant increase in production and launch rates. We will do everything that is reasonable and realistic to provide and maintain the rate of eight a year if the firm demand and commitments materialize.

So the good news is that we can increase our launch rate slightly. The bad news is that it is not going to provide much relief, and the significant increase to as many as 10 is not warranted by the business conditions today.

The subcommittee should also be aware of the practical realities, that until very recently we have had to fight and scratch for every contract that we got, particularly in the United States, which has been the toughest territory in the world. And we are going to make our long term business decisions based on a realistic appraisal of what is likely to happen and not on what we would like to have happen.

Now I will be happy to answer questions along with my colleagues.

[The statement follows:]

STATEMENT OF DOUGLAS A. HEYDON, EXECUTIVE VICE PRESIDENT AND GENERAL MANAGER, ARIANESPACE, INC.

Mr. Chairman:

I am honored to have been asked to appear here today, to contribute in a small way to an appreciation of the impact of the Challenger accident on the space launch capability of the world in general, and of the United States in particular. I would also like to express to the Subcommittee the regrets of our Chairman, Mr. Frederic d'Allest, at his inability, because of prior commitments, to appear again before this Subcommittee as he did last November. As manager of the American office of Arianespace, I have a very direct and active interest in the subject, and it is inevitable that my company should be subject to much conjecture and scrutiny as a result of this tragic loss.

You have asked me particularly to address the question, "To what extent is Arianespace capable of increasing its launch capabilities, and how likely is it that Arianespace will surge to these maximum capabilities?" The answer to this question is really quite simple and direct, and is almost a classic of the "good news, bad news" genre. It will be helpful, I think, to put the answer in the broader context of this inquiry, however. The more general question raised in your letter of invitation has to do with the probable shortage of space launch capability over the next several years and the actions we, and others, are or may be taking to respond to the anticipated shortfall in this area.

The launching of spacecraft, especially the commercial communications satellites in which Arianespace is particularly interested, has never been a "high volume" business, and never will be one. While the assessments of projected commercial launch demand have varied widely with time in recent years due to a number of factors, the estimated launch rates have fluctuated over a small range, in absolute terms. On a worldwide basis, these projections have been as low as ten launches per year in some years and as high as thirty or more, depending on the changing assumptions and ground rules. Our market estimates for the five year period of interest for today's planning, from 1988 through 1992, have been in the range of 20 to 25 launches per year, excluding specialized scientific and military launches.

This working range of 20 to 25 launches per year formed the basis of our overall production and launch planning. With a general objective of keeping our share of the commercial launch market of about one half, and taking into account the number of dedicated and shared launches we were likely to be required to accommodate, we have consistently been planning on a production and launch rate of six to eight per year over the next several years, to launch between ten and twelve satellites. To achieve even this rate has required significant, major growth in our overall capability. For example, the new ELA 2 launch complex, inaugurated with the successful launch of V17 on March 28, will allow an increase in launch rate from the maximum of six per year with ELA 1 to as many as ten, because of the separate assembly and launch areas which permit parallel operations. This is part of the "good news" I mentioned earlier.

For the record, and to clear up any possible misunderstanding, ELA 1 can only be used for the smaller ARIANE 1, 2 and 3 vehicles and is not compatible with ARIANE 4, which will be coming into service starting in October of this year. By early 1988, when we will be launching only ARIANE 4, ELA 1 will no longer be usable and will be taken out of service. During the transition period we will be using a mix of vehicles and both launch complexes will be in use, but as you will see in a short while, the limitation on launch rate is not launch facilities, but launch team and manufacturing capability. In any event, our practical launch rate limit in the future will be a maximum of ten ARIANE 4's per year.

One month after the Challenger accident, Mr. d'Allest announced at a press conference our plans to increase our launch rate to eight per year in 1987 and 1988, to be able to offer a few additional launch opportunities during this critical near term period. At the time of this announcement we had about four open slots or opportunities scattered throughout this period. The addition of two launches, one in each year, was talked about as adding four new slots, for a total of eight.

It is important to make a clear distinction here between a slot, or launch opportunity, and an ARIANE launch. Many of our launches are dual launches, in which we launch two satellites at a time. This is similar in some respects to the normal practice with the shuttle, and is done for much the same reason, i.e., to spread the fixed cost of the launch across two customers, thereby reducing that portion of the cost for each. Thus, the addition of two launches to our schedule would only add four launch slots if both were dual launches. In fact, prior commitments in the form of acceleration provisions in existing contracts caused us to commit two of these "new slots" to a single large satellite, making the practical result only two new shared launch opportunities during this entire two year period.

We are also examining the possibility of a further rate increase, up to ten per year, by adding additional personnel and scheduled work shifts at the several manufacturers who produce the hardware for the ARIANE vehicles. Our analyses indicate that this rate could be achieved in about two and a half years without the necessity for additional tooling, but only if it was to be for a limited period of time, on the order of two to three years. A permanent increase to a rate of ten per year would require more tooling and would take three to four years to implement.

As a practical fact, either of these approaches has major cost implications. Hiring, training and providing for a large increase in the diverse work force, on the order of 15% to 20%, is a major commitment. The capital investment associated with the significant tooling increase needed to support a long term rate increase is even greater. None of these actions will be undertaken unless they are justified by clear, long term customer requirements and demands for the additional launch capacity. The financial exposure and risk are too great to warrant such actions on a speculative basis.

As noted earlier in my remarks, our demand assessments and market aspirations have driven us toward a fairly consistent picture of needing six to eight launches a year to satisfy both our needs and those of the portion of the customer community we wish to serve. In this light, our recent manifest and launch schedule (prior to January 28th) of seven per year have not only been consistent with these projections, but have allowed us the slight "cushion" required to account for contingencies. These plans also had the very real virtue of using our plant capacity at efficient loading levels, which has contributed in a very real sense to our ability to keep costs under control and compete effectively in a demanding price environment.

What is required for Arianespace to undertake the actions to increase our production and launch rate to more than eight per year? The two major factors are a probable market share increase above what our previous projections have shown to be reasonable, and a much more certain, or guaranteed, demand for our services. A brief glance backward by about three months would clearly show that our manifest for the period after late 1988 was very empty indeed, making projections for the 1989 through 1992 period highly speculative. Certainly there was nothing in either the demand picture or the competitive environment which would have caused us to initiate any of the actions outlined above toward the goal of increasing our production capacity. On the contrary, the uncertainties of this period have caused us to do a great deal of careful reexamination of our plans, on a continuing basis.

All of these observations lead toward one conclusion: it has not appeared to us in the past, and does not today, that there is a clear set of indicators leading to the decision to increase manpower and plant capacity over that in place and already planned. Any such increases would require very large expenditures on the part of Arianespace, which we are not prepared to make on the basis of the market conditions and competitive environment of today.

Let me summarize all of this as it relates to the opening question:

- Arianespace is capable of increasing its launch cabability from the recent planning level of seven per year to eight, and has taken steps to do so beginning in 1987;
- This rate can be increased to ten per year for a two to three year period, through addition of personnel and added shifts, which would add four to six launches between late 1988 and 1991;
- An increase in production capacity to the maximum launch rate of ten per year on a permanent basis is feasible through large capital investment, but could not affect launch rate before 1989 or 1990;
- Long term projections and realistic international political considerations do not provide a sound business basis for making the large investment required to achieve a significant increase in production and launch rates;
- Arianespace will take all reasonable and realistic steps to increase short term capability, which will provide and maintain a launch rate of eight per year so long as firm demand and commitments for this capacity materialize.

It is probably clearer now why I characterized this as a "good news, bad news" picture. The good news is that Arianespace can and will increase our launch rate to the maximum of our present capability, eight per year, in an attempt to provide whatever assistance we can in the short term shortage situation which exists today and for the next few years. The bad news is that this small increase won't really provide much relief, and the larger launch rate increase to ten per year, either temporarily or permanently and which would provide meaningful relief, is not warranted by the business indicators and uncertainty of the competitive environment.

You should also remain aware of the practical realities in this business: until very recently we have had to scratch and fight for every contract we have obtained, and the toughest territory in the world has been right here in the United States. ARIANE and Arianespace are, as Chairman d'Allest has repeatedly said, assets of the entire free world, but only if the nations of the free world, including the United States, choose to utilize them. We will do everything possible to assist during these trying times, but we will make our long term business decisions on the basis of realistic and thoughtful appraisals of what is likely to happen, not on what we would like to have happen.

Thank you for your attention, and I will be happy to answer any questions the Subcommittee may have.

[The following information was subsequently received for the record:]

QUESTIONS OF SENATOR GORTON AND THE ANSWERS

Question. Under what circumstances would Arianespace target a market share greater than 50%, or conduct more than ten launches per year? Also, according to your statement, after 1988, launch complex ELA-1 will be taken out of use because it is not compatible with the Ariane-4 vehicle. Under what circumstances would Arianespace choose to make ELA compatible with the Ariane-4 vehicle?

Answer. A. Arianespace has not targeted a specific market share of 50%. Rather, the result of available market candidate satellites as compared to our launch vehicle manufacturing and launch rate capabilities, as well as our ability to convince customers to sign firm contracts with Arianespace, has been that our success on a worldwide basis is approaching 50%. It should be noted for the record that, as of today (May 30, 1986), of the 48 total satellites for which we have received firm orders, the total in the U.S. is 9, or 19% of the total. This includes the launch of Spacenet FIIIR as a replacement for the failure of V15 last September.

As noted in my remarks, the necessary conditions for Arianespace to increase the launch rate even to more than the currently projected eight per year (much less more than ten) are that a firm demand be evidenced, in the form of valid launch reservation commitments, for enough launches and for a far enough period into the future (realistically, at least five or six years) to warrant the heavy expenditures required to increase the rate above eight. In our view, considering today's market projections and the tendency of satellite owners to wait until the latest possible time to make the launch service commitments, these conditions are almost certain not to be met.

B. There are no foreseeable circumstances which would warrant making ELA-1 compatible with ARIANE 4. The modifications would be so extensive that, even in the unlikely event the need for more than ten launches per year (the practical limit of ELA-2) should arise, it would be easier, no more costly, and more reasonable to build another new complex. It should also be remembered that ESA is already planning to build a third complex, ELA-3, for use with ARIANE 5 beginning in the 1994 timeframe. This pad will be ARIANE 4 compatible as well, but there is no projected need for its use with ARIANE 4 except as a backup for ELA-2.

Question. From your testimony it is not clear to me if Arianespace has decided to increase its launch rate to 10 per year, even if it is only for 2 to 3 years. Has that decision been made, and if not, when will be likely be made?

Answer. It has been decided to retain the present maximum rate of eight launches per year, as controlled by plant capacity. No decision has been made to increase to more than this rate, nor is such a decision likely ever to be made, for the reasons outlined above (1.A.).

Question. According to your statement, Arianespace has a total of two additional launch slots for 1987 and 1988. Do you mean these are presently unassigned, and if so, are they the only unassigned slots during those two years? How many satellites could Arianespace accommodate with these two additional slots?

Answer. The comment in my statement was meant to describe the addition of one additional launch in each of the years 1987 and 1988, from our previously planned seven per year up to eight. These two additional launches would accommodate as many as four satellites of appropriate size and weight in the dual launch mode. As I tried to clarify in the middle of page two of my prepared statement, after taking account of other commitments to then existing customers for acceleration of their launches already booked with Arianespace, only two "new" satellite launch opportunities were added. They have, of course, now been committed, or assigned.

Question. You stated that Arianespace could achieve a launch rate of 10 per year, in about 2½ years, without additional tooling. If you made an immediate investment for tooling, when could Arianespace achieve a launch rate of 10 per year, and over what period of time could this rate be sustained?

Answer. The increase in rate to ten per year without additional tooling is based on the idea of adding personnel to create a fully effective third shift in every critical area. This could conceivably result in the increased rate becoming apparent in the two and one half years mentioned, but would at best be a temporary (and also costly and risky) approach. Even if an immediate decision were made to increase the tooling and facilities to the required level, it would not become apparent for at least three to four years, since the production of the tools and fixtures themselves is a time consuming process. If such a decision were implemented it would, of course, permit the higher rate to be sustained indefinitely.

In considering this answer, keep in mind the overriding condition of necessary firm demand, which simply does not exist.

Question. Aside from tooling, what aspect of your production effort limits your launch rate? Can this be remedied?

Answer. As noted in the answer above, both tools and facilities in one case and personnel in another are limiting factors in sustainable launch rate. Of course, all of these limitations can be overcome, *if* the demand projections indicate that it is an intelligent business decision to do so.

Senator GORTON. Thank you.

Gentlemen, this job up here on this side of the podium is a magnificently challenging one. One thing it lacks is any ability to plan your own time. We are in the last half of a rollcall right now. I have to leave. I also have an unbreakable 5 o'clock appointment. Senator Riegle will come back and ask some questions. Most of mine will be asked in writing.

I will put one or maybe two to you now, and perhaps you can answer after I have left so we have it in the record right away before those written ones, and then if you will wait just a few minutes, Senator Riegle will be back.

I would like you, if you would, Mr. Heydon, to describe the fundamental assumptions which led Arianespace to its market assessment of 20 to 25 commercial launches per year between 1988 and 1992, and then would others of you on the panel state whether or not you agree with those assumptions or what your assessments are for that market in the same period of time.

And with that, I will apologize for leaving while you are answering the question and hope you will understand our problems.

Mr. HEYDON. Certainly.

Well, I can speak for Arianespace and probably to some extent for my U.S. ELV colleagues that we continuously examine and reevaluate the launch activity expectations throughout the world. We do a detailed market analysis every year, and update it on a quarterly basis, and we attempt to cover all types of payloads, telecommunications, Earth observation, scientific, although the last two, in our case, account for a very small fraction of the total and almost always require a dedicated launch.

For communications satellites in particular, though, the key areas that we have been looking at are expansion and replacement markets, and we follow FCC and ITU activity very closely to watch what is likely to happen. In the period that I mentioned in my remarks, from 1988 to 1992, the 5-year-near-term forecast, our internal studies and those of outside consultants have showed very wide ranges, from as high as 40 launches a year to as low as 8. I think someone mentioned the Battelle study earlier, and I believe the Battelle study routinely provided for NASA carried similarly wide swings.

We cannot afford to be overly optimistic because we end up paying for unsold capacity if we do that. So we have tended to take a fairly conservative or middle of the road position, and that is where we get to the 20 or 25 on the average. We expect to see over that 5-year period something between 100 and 115 to 120 total launches of the types I have mentioned.

When we take out the small number of prior committed Earth observation scientific spacecraft and satellites, I feel these numbers are quite consistent with the NASA numbers that have been talked about for some time in the range of 16 to 20.

So, I will turn it over to my colleagues.

Allen?

Dr. LOVELACE. Well, I think if I understand the assumption base, I would basically agree. We tend to take a conservative view of it as well. I would say around 16 to 20 launches a year, if I understand the market scope that you are referring to, Doug, that would represent a reasonably conservative view of that market.

Mr. FLORA. Our assessment that we made using the Battelle model and looking at the nature of those satellites and doing a little discounting based on history got us to about a 14-to-16-satellite launch per year, and that would be in the commercial sector.

Mr. HOOD. We are looking at about the same rate, but I will tell you that we have never launched more than 12 Delta class payloads in any one year. We look at the replacement rate of the communications satellite to be somewhere in the neighborhood of 10 to 15 over a 5-year period, or somewhere, 2 to 3 a year replacement basis, and that was the market we were looking at when we went into the PAM business.

[Brief recess.]

Senator RIEGLE [presiding]. The subcommittee will come to order, please.

Senator Gorton will not be able to return, and so I will go right into some of the questions that I wanted to raise with you.

If is clear from what I think all of you have said that we need a mixed fleet, a fact that was not clear before the accident. But why wasn't that clear to everydody 2, 3, 4 years ago? I mean, why did we sort of move away from the mixed fleet at that time? Were you folks all ringing a bell for a mixed fleet then?

Mr. HOOD. Yes, sir; I do think it was clear. What we were following, however, was a policy decision within NASA to put all the missions that we could on the shuttle in order to maximize the number of payloads and spread the operating costs over a larger base.

Senator RIEGLE. Make the economics work?

Mr. HOOD. Right, you know, larger distribution of the base costs, and at the time that seemed like the appropriate thing to do. But there was a time when we tried to convince NASA that maybe they ought to take four or five Deltas and put them in the inventory.

Senator RIEGLE. So basically then, is it fair to say that the industry back some years ago felt that we ought not to just be sort of narrowing down our launch capabilities and putting everything in the shuttle?

Is that a fair statement, Dr. Lovelace? Would that be accurate?

Dr. LOVELACE. I think that is an accurate statement, Senator Riegle. Certainly my colleagues from Martin can speak for themselves, but the Department of Defense saw the need for complementary expendable launch vehicles. Admittedly, that is a program that was born in some political controversy, but it nevertheless got born. There was sufficient rationale then to cause that to happen.

There are some of us who have attempted to compete commercially during that same time period, unsuccessfully, I might hasten to add. But I think there was a recognition that for the last several years we needed a more robust capability in the United States.

Senator RIEGLE. Do you want to add anything?

Mr. FLORA. I would only comment regarding DOD, they have always had a backup policy for shuttle in its near term. That was a 2-year backup at ETR, 1 year at Vandenberg using a Titan 34D. That was the evolution of the Titan 34D program to complement the shuttle through its early years.

As the uncertainties continued and the delay at Vandenberg, more 34D's were purchased until the Air Force and DOD became convinced that the complementary expendable launch vehicle system was the right way to go and had the competition 2 years ago now.

So I would agree with that.

Senator RIEGLE. Let me just ask the three of you from domestic companies here if it were possible—first of all, is it feasible from where we are now with the shuttle program to think in terms of taking and moving the commercial business out of the shuttle program. The thought being that you use that as the way to try and bring into being some kind of a private sector launch capability, private firms willing to face all those up front money costs and so forth. In other words, is it even feasible to think about splitting off that piece of the market so that people, like yourselves, if you want to go into that business, can. And if we were to try to even theorize that, would that be sufficient to prompt one of you or a consortium to in a serious way move into the launching business here and now if there was no signal of a future policy change?

Yes or no.

Mr. FLORA. Senator, as we testified a minute ago, the premise that the Government makes a policy decision regarding the current commercial satellites being booked on shuttle, if that decision were made, if that were the will of the Government, Martin Marietta has said that they would enter that competition and compete for those satellites with our current 34D vehicle. So the infrastructure is in place, the contractors are in place, the manufacturing and launch capabilities are in place.

Senator RIEGLE. But that is sort of unique to your situation because you have got a head start.

Mr. FLORA. Yes, it is, Senator.

Senator RIEGLE. But that is an important fact.

You are saying you are in the game, and that if there were that business out there in a commercial way, you would go after it.

Mr. FLORA. And would provide an American alternative in the ELV business, certainly.

Senator RIEGLE. What would it cost you to do that?

Mr. FLORA. Well, the nonrecurring is fairly minimal because the booster exists. What we would be working on really is just applications of how we would fly a dual communications satellite launch similar to Ariane. So it is very small.

Senator RIEGLE. Now, to the other two companies, not having their built-in advantage in that respect, how would you view that kind of policy signal, if you will? Would this draw you into it or not?

Mr. **Hood**. It would not draw us into it, Senator, without being a successful winner of the DOD proposed competition for a medium class launch vehicle and having that base production to work from.

Senator **Riegle**. Is that your answer, too, Dr. Lovelace?

Dr. **Lovelace**. I think that is correct. There are three things that are going to be needed from our perspective. One of them is a clear and consistent sustaining Government policy. None of us can compete with the U.S. Government; two, the use of facilities, the use of launch facilities at a reasonable additive cost; and three, a business base to sustain that. And I think on that basis we are willing to get out and try to compete. And having said that, for none of us are there any guarantees.

But we are willing to go and face those risks.

Senator **Riegle**. Would it be feasible to do it on a consortium basis? If you could get around any legal problems, if we could find a way to deal with any legal problems that are there, would there be an interest in thinking about doing this as a private sector sort of national purpose thing. Obviously there also would be the idea in mind of making some money in the end, but would it be feasible to think about more than one company going together on this, or is this something where you really have to have a single winner that takes it and does it?

Mr. **Hood**. Well, sir, I think we are looking at different classes of launch vehicles. Certainly the Atlas and the Titan are out of the Delta class. They are more robust than Delta is, my colleagues on my left here from Martin, has got the capability over a very broad spectrum of payload ranges, so he can cover the high end and the low end both, I do not really think I could come to any real reason he would want us because he can kind of do it all himself.

Senator **Riegle**. Right.

Dr. Lovelace, do you want to add anything before I give Mr. Flora a chance?

Dr. **Lovelace**. Well, I think that in theory there is not anything to preclude some consortium being put together, but I think you really would have to look at the complementarity of the pieces of business that were being brought together, as has just been pointed out. I do not know if any of us have really done that so that we could sit here today and give you a considered answer. But in theory, you cannot discount it. Each party has got to say what are you bringing to the table, and that I think we have not done.

Senator **Riegle**. Let me ask you this. If you can try to not think just in—not that you do in the whole scope of your answers anyway, but if you try to think for the moment not from the point of view of a company response but just as a personal response, as people who have a lot of knowldege and background in this area. What would be your respective views as to what is the soundest national policy for the country from this point forward on the question of whether or not we ought to peel off the commercial side of the business and put it in the private sector in order to foster a private sector component here and restrict the future Government launches? Of course, maybe there will be an occasional unique commercial thing that only can go there, but I am thinking of restricting the shuttle at least in terms of this hypothetical to defense business, to science to and space science and to research activities.

Would hat be an intelligent national strategy decision to make at this point or not?

Why do we not just go right across, any of the three of you.

Mr. FLORA. My comment would be, first, the fundamental problem, as testified earlier by Admiral Truly and Secretary Aldridge, is we are going to have a fairly large block of satellites, albeit commercial, that will be waiting for a ride for some time, 12- to 18-month STS downtime, plus the bow wave, and with only three orbiters.

So I think it behooves the Nation as a total Nation to make some very important decisions now on how we should deal with that mix of satellites that we all know will be sitting and are not going to get up certainly in the near term at all.

Senator RIEGLE. Right, and that in a sense is part of what underlies my question.

Mr. FLORA. And if that policy decision is this group of satellites for the time being, let's say, for the next 3 years, will not fly on shuttle until shuttle catches up, then we should look at alternatives that some of the American launch vehicle companies could handle those satellites, should that be the policy or the will of the Government.

So to that end, as a person that builds expendable launch vehicles, I would say certainly, that would make perhaps the most sense because those satellites normally do not need the shuttle man tending as perhaps other satellites might.

Senator RIEGLE. Mr. Hood, what are your thoughts?

Mr. HOOD. I think that is reasonably well stated. I think as Dr. Lovelace said before, it has got to be long-term consistent policy because in McDonnell's case, we have already been burned by one proposed policy change, and that was the policy that said we are going to launch commercial satellites on shuttle, and we put our money into the upper stages, and now the policy appears to be changing.

So consistency in long term, because these are no short-term investments. These are long term investments where we are not going to recoup our dollars for probably ten years.

Senator RIEGLE. Well, and I guess I am also wondering if we are not likely to foresee a situation here where the momentum will be to build a replace orbiter, and so let's just hypothetically assume that is done, so we will be back to a four-orbiter fleet and the repairs are done, and so the shuttle is flying again, and it is a pretty expensive way to get things up there.

And we move ahead with expendable launch vehicles, and the Air Force basically is taking the lead in that area, and I am just wondering if that is not going to over a period of time leave a situation where NASA for economic reasons is going to want to hang on to the commercial business. Clearly, this business helps dig us out of the financial hole that we are in over there and they are not, very likely, going to want to give anything away to the private sector. And I am not sure that is the best policy decision. And I am not just thinking the next 5 years. I am thinking out a lot longer than that. And I am just wondering with the international competition not only at the table but as a reality, if maybe we should not be thinking in a serious way of how we bring private sector launch capability into the act here and have Government policy support that consistently over a long, long period of time. I am willing to think about it on even a cost-sharing basis in order to sort of get over that hump, but you know, later on down the line it seems to me that you would have to have a situation where NASA would not come in and sort of cherry pick the best commercial business and sort of cut the legs out from under a private sector commercial launch operation.

Mr. HOOD. I think you are absolutely right, sir. What you are touching on is the long-term viability of this market, and if NASA finds itself in a position where it has got four orbiters where they are not being fully utilized, are they going to change the policy again to accept commercial flights after they have now enticed several of us to get in the commercial business, this is a concern of mine.

But I would sincerely hope that looking at the shuttle and the upcoming space station, the total infrastructure, we would not get into that situation that having a space station there, we would increase the number of missions that are unique just to the shuttle.

Senator RIEGLE. So I guess my question really is—and then I will call on you, Dr. Lovelace, because I know you have a point to make, and that is should we as a matter of national policy and not speaking just for your companies now, should we be seriously considering peeling off the commercial business from NASA in order to try to create and preserve that marketplace so that the private sector can come into this game with the thought in mind that you can make it work financially?

Dr. LOVELACE. Well, I think that, Senator Riegle, you are right on track. I am frankly concerned that we will take and make some short-range decisions because we have got a problem, and there is not any doubt about that. It is rather interesting that there is virtually nothing we can do in terms of new launch capabilities short of maybe 30 months, 2½ years, to get there. I can certainly speak for General Dynamics—we are going out of business as far as boosters are concerned because we have been a NASA contrator on the Atlas and still are providing those and launching them. We will finish out the last of those in 1987. But for us to make the long-lead commitment to go back into that business again without any other government base is beyond our resources. Which is a similar condition I think that McDonnell Douglas is in relative to the Delta. We would not make that investment for short range, three years, because in three years you will have another orbiter back on line, and should have. I believe we should have another orbiter. But that capability is going to all come on line in about 3 years, and if the policy is the same today, then we are going to have a massive financial problem, those of us that made that decision to go into it. And I think we will not make that investment.

Senator RIEGLE. Right.

Dr. LOVELACE. Let me add one other thing. I think from a broader point of view the country is at a watershed. We can make a decision that will give us a robust and competitive industrial base for the future. I do not think as I sit here that the Atlas vehicle, much as I love it, how reliable it is and how capable it is, that it is going to sustain itself for the next century. There is going to be another generation of both manned and unmanned vehicles in our future just as surely as I am sitting here, and we need a viable industrial base to compete that and to develop it and to bring the technology along.

Senator RIEGLE. That makes sense to me.

Let me just ask our other two companies to respond to that, if you would.

Mr. HOOD. Absolutely. I could not have said it better.

Mr. FLORA. Well, I opened the remarks with the near term problem is, of course, launching this group of satellites that we believe will not get launched, and of course, in all fairness to my two other colleagues, we have the base in place, so we can, if you will, nip into the market and build some 34Ds, and accomplish the shortfall. If the decision down the road in 3 or 4 years says let's go back to a robust shuttle and fly commercials on shuttle, we have the advantage of still having a CELV base. So we really would not be hurt presumably as bad as those that made a large investment in returning to production.

Senator RIEGLE. It just seems to me, it is becoming clearer in my mind, that from a national policy point of view, we have got to gird ourselves for the long pull here. You all know that we have a problem and we need to work through it now in terms of how do we handle everything that is in the queque that we cannot put up now. And we will work it out in one way or another.

But in terms of building this industry and having it for the long pull, I think the financial incentives have to be put out there. I mean, there are different ways you can do it. The government can just sort of spend the money for it. I do not like that as well. I think I am more attracted to the idea that if we could segment off the commercial business and see that it was large enough to create a legitimate business incentive to get serious players in the act, I like that.

Maybe that is not enough. Maybe we need something in addition to that, but—we are on the second bells of the roll call which is the curse of this place because you just get into something and you have got to run to vote. But I would be interested in any specific ideas that you have as to how we might think about skinning this cat here in terms of putting something together that is the right long-term policy strategy, and then back up to sort of fitting today's decisions into that long-term strategy.

Dr. LOVELACE. If I could make one suggestion, I think there are some alternatives. Admiral Truly talked about this interim period where there is a lot of confusion.

We have got a lot of customers of the Shuttle that are not going to be satisfied. I do not think there is any question about that. There is an option for NASA for a couple of years to restart their expendable launch vehicle lines, and I speak principally now of Delta and of Atlas, and manifest the payloads. In other words, orchestrate the manifesting of payloads between the shuttle, the Deltas and the Atlas, and then get out of the business, get out of the commercial communications satellite launch vehicle business at a fixed date when hopefully by that time we can——

Senator RIEGLE. That would give you the lead time, too.

Dr. LOVELACE. Well, it helps you with the startup costs. In the mean time, we can all compete for the global positioning satellites which have also been hurt by this unfortunate accident, and we could see whether the policies are sustaining.

Senator RIEGLE. That sounds pretty interesting to me, and I would like to talk further with you about it as we have the chance to do it.

Dr. LOVELACE. But not a sustained subsidy, because I dislike that word as much as my colleagues from Ariane. Somehow you have got to help the industry get back up on its feet and make the industry robust, and as you do that, then you are going to have a robust launch capability.

Senator RIEGLE. Well, I thank you. I wish we could talk further right now.

You wanted to make one comment, if you can do it very briefly.

Mr. FLORA. Well, I was going to say it really has to be a market assessment, though, in terms of how many expendable launch vehicles in the United States with some on shuttle perhaps that require manned, and with the Ariane being in a very good position. We must continue to evaluate how many expendable launch vehicles can survive. You know, we may be tearing at each other. Certainly one system may win out in the competitions, but in terms of subsidy, that becomes difficult if we continue to subsidize two or three manufacturers.

So we would be concerned that that just adds a third party and adds more Federal costs again.

Senator RIEGLE. Well, we will talk more about this because I think these are the questions that we need to crack open, and it is a little frustrating when we get to them at the tail end of the day.

But I appreciate your testimony.

Thank you.

[Whereupon, at 5:21 p.m., the subcommittee recessed subject to the call of the Chair.]

NASA AUTHORIZATION

WEDNESDAY, APRIL 23, 1986

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE,
Washington, DC.

The subcommittee met, pursuant to notice, at 9:35 a.m., in room SR-253, Russell Senate Office Building, Hon. Slade Gorton (chairman of the subcommittee) presiding.

OPENING STATEMENT BY SENATOR GORTON

Senator GORTON. Welcome to this hearing of the Subcommittee on Science, Technology, and Space as it continues its review of NASA's fiscal year 1987 budget request. Today's review will focus on NASA's program to develop a permanently manned space station.

Since the inception of the space station program in fiscal year 1985, this subcommittee and its parent committee have supported the program because of the obvious capabilities that a space station will enable, and just as importantly, because of the capabilities and discoveries that are not obvious or apparent at this point in time. These reasons appear no less valid today than they did 3 years ago.

Now, however, as a result of the space shuttle *Challenger* accident, we are forced to examine our entire space program in the context of how we reconstitute our launch capability and how this effort will affect other space programs on our national agenda. Today we ask those questions in the context of the space station program, with particular emphasis on the likely effect on the scope and timing of that program.

As for the means by which a space station would be deployed, assembled, and maintained, I am of the opinion that a three-orbiter fleet simply will not support the space station activities. Last week before this subcommittee, Admiral Truly of NASA and Secretary Aldridge of the Air Force testified that if the *Challenger* is never replaced, there could be far too few flight opportunities for NASA, a situation which would bode ill for NASA's space station program. Therefore, today the subcommittee will reexamine the reconstitution of our space launch capability in the context of our space station program.

The subcommittee will also examine two other aspects of the program—scientific utilization of the space station and international participation in it. Certainly, out of necessity, the space station program should be structured to ensure optimal scientific utility of the facility while balancing those interests with the interests of the other space station users.

As for international participation, our potential international partners are focusing their own resources and activities toward the initiation of space station development in fiscal year 1987. Today, the subcommittee will explore the geopolitical implications of this international participation vis-a-vis our own national concerns and considerations.

The space station faces its most strenuous test to date in the fiscal year 1987 budget process. The total Federal budget is being squeezed by the realities of having to attain certain budget deficit goals. These pressures and the budget pressures that have been created by the *Challenger* accident have injected an overwhelming degree of uncertainty into any attempt to write a realistic and meaningful authorization bill. In addition, we cannot overlook the importance of maintaining balance among all of NASA's programs and ensuring that one program does not profit unreasonably at the expense of others.

With these thoughts in mind, the subcommittee welcomes the distinguished witnesses here today, witnesses who will share their insights and ideas on issues confronting the subcommittee.

Senator Riegle.

OPENING STATEMENT BY SENATOR RIEGLE

Senator RIEGLE. Thank you, Mr. Chairman.

While we are here today to discuss the space station, as appropriately we should be and need to be, I think we have had two very significant recent developments which I think will require us to do some additional work that does not relate directly, one for one, to the space station but has a bearing on it. And one that I am thinking of is the explosion of the Titan rocket last week and the fact that we have now had two major explosions of Air Force launched vehicles in addition to the *Challenger* disaster.

So we are talking, I would think conservatively, and those three accidents over a span of less than a year, of the loss of a minimum of $5 billion of strategic national assets, not to mention the lives lost in the *Challenger* accident, the seven magnificent astronauts, including a civilian woman and mother of two children, but the pattern that is emerging here of difficulty resulting in enormous dollar loss and perhaps even more importantly, a disruption of our ability to carry out certain very important missions for the country, some of those national security missions.

Something is wrong here when we see this pattern of accidents happening this way with this kind of frequency. And to find us now reduced to the point where we are quite unable to carry out planned missions that are very important to the security interests of this country, those accidents take on a larger meaning and I think it also raises some serious question about our planning, leading up to the situation that we find ourselves in now.

Now, later on this afternoon, we're going to be having the opportunity to question Dr. Fletcher, who is the proposed new head of NASA, and we can raise some of those issues at that time, although as I say, they have a bearing on what our capacity is going to be to move ahead with a vital issue of the space station, which I will shortly address in some detail in the remainder of my opening comment.

But I must say, the pattern of difficulty that we are seeing here with our space efforts is very disturbing to me, and I do not think it is just a matter of incidental issues or problems. It seems to me that we have got some very fundamental problems that underlie this kind of a recent pattern of events and how we come to grips with it and deal with it and solve it is a matter of the most urgent kind of national priority in my view.

So I think much more work is going to have to be done. It is going to have to be very hard-headed work. I think we are going to have to challenge a lot of the previous premises and assumptions, and I want to make sure that as a nation we resist any bureacratic impulse. And all bureaucracies have this impulse to sort of paper over problems. I think we have got problems here that cannot be papered over and should not be papered over. And to the extent that I for one can help see that they are not papered over, they will not be.

But something is wrong, and we had better figure out what it is, and we had better fix it, and we had better fix every aspect of it.

To the extent it is mechanical error, driven by launch pressures or bad judgments or mismangement or whatever it is, those problems are going to have to be fixed, every single one of them fixed, the mechanical difficulties from O-rings, right across the board to everything else that is an identified problem area. A lot of these problems have been hanging around for a long period of time, were well-identified and were not fixed. Well, they need to be fixed and I intend to see, for what I can bring to bear on it, that they are fixed.

Second, I think we have got procedural problems in terms of how some decisions are made and how they are carried out, and that has to be examined. And if the procedures have to be changed, then they have to be changed, whether it is signoff for launch or how we identify and correct difficulties in the system.

I think there is plenty of evidence around now to suggest that there have been some management misjudgments as well, particularly with respect to the *Challenger* in terms of public testimony already taken by the Rogers Commission, but I think we are also seeing here a breakdown in some of the decisions made by specific individuals, and I think we have to be just as relentless about identifying those problems as we do mechanical or procedural problems.

If there is a fourth category of difficulty, whether it is insufficient oversight, if Congress has fallen short, if public pressures are seen as too great to try to maintain too ambitious a launch schedule in light of other uncertainties and difficulties, and there may be a fourth category of problem that needs to be addressed in quite a different way, so that we are realistic as a nation in terms of what we set out to do and what we hold people to in terms of a standard of operation that is achievable and sound and workable from the point of view of both safety and our financial capacity.

So all of these areas I think have to be looked at very, very vigorously. And I must say, in reading the story in the *New York Times* today—and I would ask, Mr. Chairman, that that article be made a part of the record at the conclusion of my remarks.

I find it a very distressing and disturbing article and it has obviously been researched carefully in terms of looking at a host of problems over a long period of time on the management side of NASA, pile-up of difficulties, overspending, a lack of tight enough control, and it does not cause one to stretch their imagination to go from that kind of pattern of difficulty found by Government audits numbering in the hundreds to the current pattern we are seeing of, I think, an unusually and unacceptably high number of accidents and catastrophic accidents where entire missions are being lost, including the people aboard.

So I think we are at a point here where we are going to have to take a very searching look and insist on stripping everything bare until we find out where these problems lie.

In fixing them, there is no room for smugness, there is no room for arrogance, there is no room for bureaucratic or institutional resistance to want to face hard facts, and I think we have to be relentless in digging through this problem. In the end, that is what is best for the country.

If things have to change, as I am convinced now many things do have to change, then we have got to get about the business of changing them. And people that want to defend the status quo, when the status quo is not working properly, I think that is not acceptable.

So I would hope—and I will just say it now so that everybody is on notice, including Dr. Fletcher when he comes this afternoon—I want to be sure that whoever is running NASA in the future is prepared to challenge every single operating assumption and, there are bad mechanical problems, to insist that they be fixed, period; that if there are bad procedural problems—and I think clearly there were in the *Challenger* case, and I think that is the stated conclusion already of the Presidential conclusion—then they have to be fixed and changed.

If somebody is determined to say, well, we cannot change it or it is working fine, or there is no problems, or nobody has done anything wrong, then that is not the person to head the agency in my view.

The third thing is that people do make decisions, and if they do not make the proper decisions and lives are lost and billions of dollars of equipment are lost because procedures are not followed properly and concerns are not raised to the right level of management, then I do not want those people around making decisions in the future, jeopardizing the assets or the people.

I think in matters of this kind of incredible national importance and strategic implication, that we have to have absolutely unassailable decisionmaking processes and people making them, and if people make big, devastating mistakes in judgment, I do not think they should be given a second chance.

That is how I feel about it. Others may disagree, but I think that sets exactly the wrong example. If we are going to sort of gloss over things and escape the fact that there is human dimension in this as well, then I think we fail ourselves. I think the astronauts have a right to expect that we are going to be just that tough and just that rigorous and I want to see it, I want to see it up and down the line in NASA, and I want to see it in the next Administrator.

I will just say one other thing along that line, and that is a concern that I have with respect to Dr. Fletcher. And I have met with him privately; we had a very good conversation, and it was a very forthright discussion. I thought he was very frank in his responses to me. I must say I am disturbed about many of the things that I read in this *New York Times* article today, but beyond that, what I do not want to see running this agency at this time is somebody who is a defender of the status quo or somebody who is part of a network or would feel part of a network of individuals, processes, procedures that may have worked at one time but may not be working today.

So I want somebody in that job who can take a fresh look and who is prepared to make whatever changes are needed, and if friends have to be moved out of key jobs, move them out. If that is necessary, move them out and move somebody else in, because this is not a private fiefdom for individuals or anybody else. This is an essential national security effort in my view, and it belongs to the American people and I think they have to have the assurance that we are being as tough and as rigorous in every aspect of this program as we possibly can be.

If we are not, we are not going to continue to get the funding. That just follows in my mind as sure as day follows night, that we are not going to get the funding in the future in the amounts needed if we cannot establish and retain the full confidence of the Congress and the American people in how this program is being run, both the NASA part as well as the Department of Defense part, which is now twice as big as NASA in terms of space efforts.

So I think we are at a point here where, with the Gramm-Rudman pressures and other pressures, we are going to have to make sure that we are as tough in managing ourselves in these areas as we possibly can be, and that is the kind of management team I want to see. And unless I am convinced that we are going to have that, then I am not going to be able to support people for those positions.

I hope that we will be convinced, all of us, that we are going to see that in terms of the team that is now being put into place and the nominee that is coming before us, but we will have to ask some questions along that line later today.

Mr. Chairman, I thank you for your indulgence. I would like now, if I may, to make some comments on the space station.

This is clearly a critical part of where we are going in the future here, and we have examined already our launch capabilities, both near term and long term. And now we are focusing today, of course, on the space station program.

Any discussion of America's future in space I think has to address in a central way the space station. In my view, we have to move ahead with it. It is not a question of if; it is a question of when and how, and how we actually go about doing it in terms of the exact configuration.

I say this for many reasons but one of the key reasons that other nations have already decided to move in this direction and it is very significant to me that the Soviet Union has launched and is now operating a space station successfully.

It is, by all accounts, fully functional and the cosmonauts for the Soviet Union are performing important experiments in all aspects of commercial development, from materials processing to ultrapure drug production.

Clearly, they intend to remain in space and to develop in a determined fashion, the full range of commercial and scientific possibilities. I think we have no choice but to proceed as well and I would say that, even if we were not facing that kind of international challenge by an adversary, because I think the gains that are to be had if we do this intelligently from a Space Station, are manifest for a nation over a period of time, and I do not think we can forego or should forego that opportunity or cede it to anybody else.

We have made good progress to date in the early development of the Space Station. It is the most international of all of NASA's programs. Foreign participation was one early criteria that NASA has embraced and which has produced tremendous results.

Canada, long a partner in the space program, has been an early enthusiastic participant in the definition phase, along with Japan and the European Space Agency. I think these are important facts. The public needs to know this.

We are now faced, however, with some very difficult decisions. Two events have coincided to throw great uncertainty onto the Space Station, uncertainty especially as to how fast we can move from the design to the construction phase.

Those two events were the Challenger disaster which I mentioned, which has been profoundly disruptive in so many ways, and also the passage of the Gramm-Rudman-Hollings Budget Act which is now the law of the land and a potent new fact of life for any Federal Government spending venture.

Because the Space Station will require huge investments of time and space in the shuttle itself, and with a three-orbiter fleet, which is what we are reduced to at this time, that makes it very difficult to take and set aside the amount of shuttle launch capability that is needed for the space station when one weighs it against other strategic military and defense requirements that the shuttle also has to carry out, once we are back up and flying.

I serve on the Budget Committee with the chairman of this subcommittee, Senator Gorton, and with Senator Hollings and we have reported a resolution that is on the floor now which assumes a 1-year freeze in spending for the space station.

I supported that resolution in the overall, as did Senator Gorton, in my own case, despite reservations I had about the wisdom of that particular freeze, because on balance the resolution as a whole meets the Gramm-Rudman targets in what I consider to be a very responsible fashion.

But this is clearly an example of an era, the Gramm-Rudman era that we have entered, and we are now going to have to make all future budget decisions in very strict conformance with guidelines that are now a matter of law, and you should bear in mind that the Gramm-Rudman deficit reduction targets are $144 billion this year, coming down from roughly $200 billion, which is a very tough step to take fiscally in terms of its implication on programs.

But the following year we have got to take the deficit down by law to $108 billion and the following year to $72 billion. Now, those are very substantial restraining steps which I think are needed, and are needed for reasons of fiscal management and also for improvement on interest rates and other things, that has to be done.

The point is, it is going to have a profound bearing on every decision, and the space station clearly is in the line of fire of the implications of what that means.

So while I am convinced that we will have a space station and I think my views are shared by all members of the subcommittee, I think the question of when we are able to have it and the speed with which we are able to get it and how we will go about doing it is a much, much tougher problem.

So I look forward to what the witnesses have to say today. I think we are going to have to work importantly together on this, to try to work our way through these questions and difficulties to a successful conclusion, which is where we have to end up.

Thank you, Mr. Chairman.

Senator Hollings has an opening statement for the record.

[The statement follows:]

Opening Statement by Senator Hollings

Mr. Chairman, we have arrived at a critical point in the space program. One of two things can happen today. Either we will hear compelling testimony that will justify the initiation of Phase C/D of the space station program or we will hear rhetoric, rhetoric that might be convincing to NASA but that will have little weight with the members of this subcommittee or the Members of the Congress when it comes to fiscal year 1987 space station funding. I hope the former occurs because these are hard times, and members are being forced to make hard decisions. Not everyone or every program will be a "winner" in fiscal year 1987—there just aren't enough prizes to go around.

Already this year, the Senate Budget Committee has reported out a budget resolution, one currently pending on the floor of the U.S. Senate, that assumes a freeze for the Space Station Program in fiscal year 1987 at the fiscal year 1986 program level—approximately $200 million. As a member of the Senate Budget Committee, I can give you two reasons for this assumption in the budget resolution—as a result of the shuttle accident, there are more demands from NASA than there are dollars available, and NASA has not convinced the members that the space station is time critical. Hopefully, those perceptions will be corrected today—hopefully.

Mr. Chairman, as I look at where our space program is today, I recall 1957 and the challenge presented by the Soviet success with Sputnik. One would think the recent deployment of the third generation Soviet space station would have ignited the American public, NASA and the Congress as in 1957—but it didn't. Too many people have been lulled to sleep, have come to believe the race for space ended with the landing of the first man on the moon. I have news for these people—the race for space continues. Unfortunately, as of late, the United States is approaching this race as did the hare in its fabled race with the tortoise—without resolve. Leadership in space is not something that can be maintained with a weakhearted commitment. It requires support—financial support, public support, and moral support.

In the aftermath of the shuttle disaster, it is hard to focus on anything but the shuttle. However, Congress must decide this year if we are to proceed with the Space Station Program in a timely manner. The U.S. industrial community is watching, as is the international community, to see if the United States is committed to this program, if it has the resolve to move forward, to lay a foundation for future space activities.

Mr. Chairman, I think it is critical that the subcommittee and the Congress find a way to initiate the hardware development phase of the space station program. I think it is critical that we respond to the challenges from abroad and the challenge of outer space and that the United States move with resolve to establish a permanent presence in space.

I look forward to today's testimony, and I look forward to hearing many compelling reasons why the Space Station Program should be a priority in fiscal year 1987.

Senator GORTON. Thank you, Senator Riegle.

Mr. Hodge, we will proceed with you. I appreciate your introducing your two colleagues. Your written statement will be included in the record, and if you would we would appreciate your summarizing it.

STATEMENT OF JOHN D. HODGE, ACTING ASSOCIATE ADMINISTRATOR FOR SPACE STATION, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION; ACCOMPANIED BY DR. TERENCE FINN, DEPUTY DIRECTOR, POLICY AND PLANS DIVISION, OFFICE OF SPACE STATION; AND JOHN SHEAHAN, ACTING DIRECTOR, BUSINESS MANAGEMENT DIVISION

Mr. HODGE. Thank you, Mr. Chairman, for inviting us here today. I am very pleased to be here. I have with me Dr. Terence Finn, who is the Deputy Director of our Office of Policy and Plans in the Space Station Program Office, and Mr. John Sheahan who is Acting Director of the Business Management Division.

I would like to make a few remarks before answering your questions and thank you for entering the prepared statement for the record. It is now almost exactly 4 years since Mr. Beggs asked me to put together a task force, the Space Station Task Force to examine the need for and the characteristics of a Space Station Program.

We started that in May 1982 and the culmination of the efforts of that organization ended with the President in the State of the Union Message on January 25, 1984, directing NASA to go ahead with the design and development of a permanently manned space station, and to do that within 10 years.

Shortly after that and during that period, we had brought together both the capabilities of NASA and the aerospace industry to examine that question of why a space station was a reasonable thing to do and what it should be.

Following the President's announcement, we put together a Space Station Program Office which expanded the participation on the part of NASA. We brought into that four of the major centers of NASA: the Johnson Space Center, the Marshall Space Flight Center, Lewis Research Center, and Goddard, an amalgamation in many respects of both the manned and the unmanned aspects of the NASA programs of the past, and again looked at the question of what a reference configuration should look like as we moved forward into the preliminary design of the space station program.

In that context, we brought on board very shortly, about a year ago, eight of the major aerospace contractors in this country representing a very large percentage of the capability that we have in this country in the aerospace area.

They have been working for a year now and that year's efforts culminated on April 1 of this year when a team from the centers, headed by the program manager from the Johnson Space Center, the lead center for this program, made a 2-day presentation to me with regard to their readiness to proceed into preliminary design in the next few weeks.

I am now ready to recommend to the new Administrator that baseline. I believe we have done an enormous amount of work in the last 4 years and that has increased in tempo over the last year. I believe we have a program that we can proceed with and proceed with in a judicious way and very rapidly.

The bottom line is that we are ready to go. I think that we have, I know that we have a program where we can justify the cost, the content and the schedule that is consistent with the needs of the users of this facility, the set of facilities that we are putting together, and that we are ready to proceed with.

We have in place a NASA team. Many of the centers are involved in that. We have an industry team that is ready to go and is anxious to proceed to the competition so that those who win can go ahead with the program and those that lose that competition can move on to other things.

In addition to that team that we have put together, and which I personally am very proud of, we have participated wth our international friends and allies overseas who have enthusiastically gone along with us in working with this program.

We are now very close to agreement with all of those as we proceed into the preliminary design phase of the program. We have program level agreement, ratification of that agreement from Canada; a similar program level agreement with Japan, and a ratification of that agreement We have program level agreements with ESA and we expect ratification of those agreements within the next few weeks.

It would be remiss of me to talk about the Space Station Program without talking about the tremendous effort we have made to make sure that this set of facilities—and I use the term "facilities" because we are talking about permanent facilities in low earth orbit rather than spacecraft—and that the capabilities of those facilities have been driven by the needs of the user. It is absolutely essential as we move forward that we begin to make the business of being in space business and routine and that we learn how to operate efficiently and inexpensively and that we do it on a permanent basis.

The time has come for us to take advantage of what we have learned over the last 27 years in the space program.

In 1984 when the President made his statement, and I would say that he repeated it again in the State of the Union Message in 1985 and again this year in 1986, he stated that the question of being in space is a matter of leadership.

I heartily endorse that. I believe that over the last 25 years, the United States has demonstrated through its Space Program that we are in a position of leadership and it is essential that we maintain that position of leadership as other nations recognize that there are things to do in space and that we must be there.

I want to leave you with two messages. After the presentations that I have heard over the last few weeks from all of the participants in the program, we are indeed ready to go. It is time for us to proceed to the development phase of the program.

In addition to that, I would like to say that as we make this decision, it is a signal not just to the Nation, but to the rest of the world, that we are prepared to retain the leadership that we have demonstrated over the last 25 years.

Thank you very much.

Senator GORTON. Mr. Hodge, Senator Riegle in his opening remarks referred to a story about a series of critical audits in various operations of NASA which appears in this morning's *New York Times*.

Do any of the audits referred to in that story deal with any of the operations of your portion of NASA and your program in the course of the last 3 years, or have there been any audits by the NASA Inspector General or by any outside people that have spoken critically of your operation?

Mr. HODGE. I read that article in the newspaper this morning, sir, as you did. I am unaware of any items related to that story which are associated specifically with the space station.

Of course, as the program has proceeded over the last 4 years, there is the normal routine auditing of all of the work which we do. I have not been approached by the Inspector General or by our Office of Procurement with regard to any peculiarities or irregularities as we have moved forward with our program.

I am not aware of any such things.

Senator GORTON. I gather you intend to keep it that way?

Mr. HODGE. Absolutely. We really, I would like to say in that respect, that we do a great deal to make sure that our programs are carried out with great rectitude. The Source Evaluation Board process within NASA is as rigorous as I have seen in the U.S. Government.

I think in that respect, we make sure we are in a truly competitive environment and that we do maintain rigorous program control as we move through the various phases of that program.

Senator GORTON. When you first came to this subcommittee asking for authorization to go forward with the Space Station Program, the estimate was that the space station could be designed and put into orbit and made operational for approximately $8 billion.

Is that still your estimate? How well have you kept up with that proposal?

Mr. HODGE. I think we have kept very well to that, and yes, unquestionably, that is still our estimate.

What we had to do during the past year was, first of all, put together a reference configuration, a set of capabilities that we thought were responsive to the user requirements, that certainly didn't meet all of them, but that were a reasonable set of user requirements and the configuration that was compatible with those.

That, in fact, is the purpose of phase B of our study, to look at what our aspirations were a year ago and then to examine those in the context of the evolving design as we begin to understand that more; a continuous reassessment of the requirements that go along with that, and the estimate of cost and schedule that goes with that.

Just before Christmas as we were beginning to complete our examination of the reference configuration, it became clear that we had to examine what we were trying to do in the context of the realities of the budget as we looked forward to the next several years.

We had given ourselves several targets. One was that we would like—we believed it was necessary for us to make a first element launch, the launch of the first piece of the space station late in 1992 or early in 1993.

We had also said in response to the President's request that by 1994 we would have a fully manned, permanently manned capability. As we began to look at the balance between the budget realities and what our aspirations were over the last 3 months, we have begun to play those two things together.

It is now apparent to me that we will be able, with a hardware start in 1987, with the knowledge of what our international partners are providing for the program, that we will be able to meet a target date of January 1993 for the first element launch, and that in 1994 we will be able to have a permanently manned capability, with somewhat reduced capability than we were talking about for the reference configuration, and that within a year or so of that time we will be able to produce a baseline configuration for $8 billion which substantially meets the requirements of the users that we put together a year ago.

Senator GORTON. I understand now that the facility that will be operational by 1994 is estimated to cost on the order of $6.6 billion, rather than $8 billion.

What kind of capabilities did you remove from that 1994 goal as against what you would expect to get for the original $8 billion?

Mr. HODGE. That number, $6.6 billion, is difficult to put in context. If you look at the runout of our budget estimates through 1991, the total amount of money which the administration is proposing for the design, development, test and engineering function, DDT&E, for the space station through 1991 is $6.6 billion in 1987 dollars, somewhat less than $6 billion in 1984 dollars which is the correct reference relative to the $8 billion.

The full $8 billion that we have been talking about would run out over 3 or 4 years beyond that timeframe.

What we are proposing is that in fact we have stretched the schedule; in other words, all of the pieces of the baseline configuration would be under design and development during this whole period; that piece which would be available and flying by 1994 would be somewhat less than the baseline configuration, although in fact the other pieces would be in the stream of design, development, and production.

The pieces which will not be there in 1994 and not up and flying, although in production at that time, are parts of the pressurized volumes, mainly the attachment nodes and tunnels which put the pressurized volumes together.

Most of the international parts would not be up and operating at that time, although they too would be in the production stream at that time. The piece that is the exception to that is the Canadian Mobile Remote Manipulator system which is part and parcel of the construction of the facility and some of the platforms would not be up and operating at that time, although they too would be in the production process.

The majority of the money which takes you out to the $8 billion would in fact be the completion of the production test evaluation and launching of those facilities, rather than not having those in the system at all.

So in fact what we would have up in 1994 would be a large percentage of the U.S. part of the program with the exception of the connecting devices that we would be using for the international participation. We would probably have one of the two platforms up and operating, although the other is planned to be launched very shortly after the 1994 timeframe. A significant amount of the power, we are proposing in the first permanently manned configuration that we would have 25 kilowatts of power available. In fact, on this model you can see that is the polar voltaic part of the system. The solar dynamic part which is the advanced technology and the much more efficient part of it would be put on later, although it would be in the development phase at that time.

Senator GORTON. In your written statement you stressed the significance of initiating Phase C/D development in fiscal year 1987.

What are the likely consequences for NASA if you do not receive funding in 1987 sufficient to initiate Phase C/D both on your own program or on the international cooperative program?

Mr. HODGE. It is very difficult to answer a question like that because when you put a program like this, of this kind and this magnitude, and you put it together over a period of several years, it is like if I can use a paradigm, it is very much like getting a team to the peak of capability just before the championship game.

What you have to do is coalesce the team itself, the building of the team, both within NASA and within industry. You have to coalesce the teams, the international teams that will be participating with us. You have to describe and understand the management processes that go along with that.

In parallel with that, what has happened—in fact we now have Canada, Japan, ourselves, and ESA representing 12 or 13 nations, coalescing their whole budget cycle to culminate in decisions this year. In fact, those decisions have been made by two of our international partners and the third is very close to that.

There is already an agreement in principle with regard to the budgets. We have been doing the same thing with regard to our industrial teams. What we have done is bring them along the same way. They have invested their own money while we have been investing our money as we begin to bring this type of capability to culmination.

Our industrial teams want to get on with the competition so they can see whether in fact they have won or not, to spend as much money as necessary to compete and to win, but if they lose, to get out of the program.

We have raised that expectation with everybody. We have prepared the team and it is my personal belief that unless we move ahead with the design and development phase, we will go off peak. We will reduce the efficiency of the system and in fact there is a great danger of this conglomeration of rather complicated decision-making, that that will in fact begin to unravel.

I think we are in danger of putting the program as a whole in jeopardy if we do not go ahead as we planned.

Senator GORTON. What is the mininum level of funding below $410 million which would support a productive start on the space station?

Mr. HODGE. Every program manager is faced with that dilemma. As we have moved through the budget cycle over the last several years, we have said that for reasons of efficiency and program management, that it was appropriate to spend somewhere between 5 and 10 percent of the expected budget for the program in order to understand what it was we were going to go ahead with.

With the accommodation of this 1987 budget, we will have done that. We will have spent about 8 percent of our budget in preparing and understanding and defining in great detail what it is we want.

As we went through the budget process this year, it became clear that as responsible members of the administration and of the career civil service, that we had to examine the numbers that we were looking at in the context of the total runout budget and in the context of what was the right amount of money to have to start the program off with.

You will know from previous statements that in fact we asked for $270 million to go ahead with the development phase of the program. As responsible individuals—and I think we did this very well—we looked precisely at what we were trying to do and decided what was the absolute minimum that we could do consistent with fiscal responsibility and program responsibility.

I believe that the $150 million that we have put in there for the development phase is the bottom line. We have already examined that in great detail and I think it would be unwise to move into the beginning of the program with less than that amount of money.

Senator GORTON. How many shuttle flights will be required to establish the initial orbital capability and the initial operating capability, and when under the present plans do you expect to fly those missions?

Mr. HODGE. One of the reasons that you do phase B's, phase B studies is to examine your initial premises. As I say, we had the reference configuration. We understood what the weight of that would be and it included both a man-based and the free-flying plaforms, along with that.

As we have gone through the year, one of the most important things that has been done over the past 3 months is to examine the assembly sequence. It is really a very tricky arrangement, particularly the manned base, because each piece that we send up there has to be stable and operating by itself while we are waiting for the next flight to come up.

In order to assemble the U.S. part of the system that includes the space station itself, the platforms and the logistic resupplies that go along with that, we need a total of 19 flights.

Now, of that 19, 11 of them are associated with the assembly of the U.S. portion of the manned base. Two of them, of course, go along with the platforms, one of which goes out of Kennedy and one of which would go out of the west coast. And 6 of those 19 flights will be associated with logistics and resupply of that capability.

In addition to that, we need six flights to launch and assemble the international parts of that program. And that gives you a total of 23 flights that would occur over a period of about 3 years.

Senator GORTON. Can that be accomplished with the three-orbiter fleet?

Mr. HODGE. Our assessment in the number of shuttle launches required to pursue that schedule and that number of flights is that we will need between 8 and 10 flights per year and depending on how you look at the potential capability of the shuttle to launch and the rapidity with which you can launch, the schedule in that timeframe, that is the equivalent of 1½ shuttles.

So the space station, during the launch and assembly phase and in fact as you begin to look into the operation, the mature operation of the space station requires about the equivalent of one and one-half shuttles.

Senator GORTON. That is an interesting answer, albeit not a direct answer to my question. I assume, however, that given DOD priorities and given the necessity or the heightened desirability of the number of missions not connected to the space station, that it would be exceedingly difficult to accomplish this task in a timely fashion with three orbiters.

Is that correct?

Mr. HODGE. Yes. I think that is the right answer. It is incumbent upon me to examine the space station in the context of that matched pair of the shuttle and the Space Station Program and how many shuttles will be required to perform that.

It is also incumbent upon me to argue in the forum of NASA, the NASA question of how large a fleet is an appropriate fleet and what are the potential manifests of that fleet during that same period. My personal opinion is that a robust capability is probably larger than three orbiters. That decision was made several years ago. It was determined to be four.

In this forum and other forums I have discussed questions of larger amounts than that. This is a national transportation system and I think perhaps it transcends even the question of whether NASA itself believes that that is a correct number.

My personal belief is that in order to meet all of those requirements and to maintain leadership in the space business, that three is probably not a robust national transportation system.

Senator GORTON. Will the space station have the capability for docking expendable launch vehicles?

Mr. HODGE. We have examined and reexamined that question several times over the last few years. The question is really a tradeoff between the design and development of new systems as against the maturing of the systems which we presently have.

There is no doubt that it would be possible to build expendable launch vehicles with a fully automatic docking capability which we presently do not have, and an unmanned reentry capability for those things which have to come down.

As you examine the question of logistics associated with the space station, once you have assembled the space station it is generally true that what goes up must come down—but not quite. You actually leave a little up there. So you cannot answer that question totally in the context of is it possible to do it. More, is it appropriate in the context of the total national space transportation system, whether some of the capability should be done with expendable launch vehicles vis-a-vis the shuttle itself.

The space station has today been designed, as I said, on the understanding of the original plan which was put together in the early 1970's, that the space station and the shuttle were a matched pair. It is possible to do that. Whether it is fiscally appropriate to have that kind of dual capability requires a great deal of study and unquestionably a great deal of expense in design, development, testing, and engineering.

Senator GORTON. From your own personal perspective, is it wise to rely upon a single means of space transportation?

Mr. HODGE. The decisions that have been made over the last couple of years are associated with whether or not we should have a complementary system. And I do not necessarily mean by that a dual system, but a complementary system, something which is available just in case. And I endorse that.

I believe that it is not unwise to have a single capability, providing we understand and demonstrate the reliability of that single capabilty. The shuttle is built with a great deal of redunancy. Obviously, something went wrong. We lost a shuttle and we were delayed a year.

We have to reexamine that question of the suitability of a single capability. But when you get down to the bottom line, we still have to have an up/down capability. The shuttle met that requirement and I think will continue to meet that requirement.

The question of whether you need a backup or complementary system to go along with that is going to be a subject of continuing debate, I am sure, over the next several years.

Senator GORTON. Senator Riegle.

Senator RIEGLE. Thank you, Mr. Chairman. I want to get into some questions with respect to what the Soviets are doing. Would you agree that they are clearly ahead of us now in the space station competition?

I mean they are up there operating, and we are not.

Mr. HODGE. There is no question that they have, over the past 15 years, been working diligently on the business of putting man in space permanently. They have put up a total of seven temporary facilities with increasing capabilities over that period of time.

They have demonstrated they can stay there for long periods of time. They have more recently put up a facility which they say is moving toward permanence in space. As a result of that, they have lots and lots of experience of manning space in the context of space station capability.

They do not have a resupply facility similar to ours, the shuttle itself, the up/down capability. From the popular literature, it is apparent that they are beginning to consider that subject. We believed as we put our program together that it was necessary to have the transportation system in place before we built a fully permanent manned facility.

Remember, though, that in the period that this was going on, we did run Skylab and one of the major things that came out of the Skylab missions, three missions in all, not permanent but culminating in a 3-month mission, gave us enough experience and knowledge to know that it was OK to build a space station with a zero G basis because that was one of the serious questions which was unanswered in the early 1970's.

Senator RIEGLE. Well, given the fact that the Soviets had decided a long time ago to concentrate in this area and to work hard at it, they are up there now, they are operating. How many years ahead of us are they at the present time?

Can we express where they stand versus where we stand? We are still on the drawing boards and they are up there operating. Now, I see a real gap here and I am wondering, how do we size this gap? How far ahead of us are they and how long is it going to take us to equal or pass what they are doing?

Mr. HODGE. They have in place right now what is the beginning of a permanent capability. With regard to the knowledge base that is required to build such a system, I believe that we know as much about what needs to be built as they know. They simply have that capability in place right now.

We have a fully reusable transportation system; they do not. We are proposing to build a relatively sophisticated capability, a very capable space station by 1994. During that time, presumably they will do some more things. From what I can tell from the public literature, the capabilities that we are talking about in 1994 have functions which exceed what I see presently out there.

We are talking about a large volume. We have introduced another couple of concepts. No. 1, the servicing of unmanned satellites. That takes a long time to do because you have to build the satellites to be serviced, as well as to build a servicing capability.

And we have now embraced that basic concept so that by 1994 we will have a servicing capability and serviceable assets in space at that time.

Senator RIEGLE. Let me ask you this. This is the thing that I find troubling. That is, the Russians decided to put more emphasis in this area. They have a functioning space station and they have people up there now. And our plan, if everything works, is to have us with our different, more elaborate space station up there in 1994, so that is 8 years from now, and so in a sense they have got an 8-year lead in the sense that they are up there and it is going to be that long before we are up there.

Now, they are not going to stand still. They are obviously refining their techniques and what have you, plus they have been up there for a time. I understand that they have conducted—and I would like you to confirm whether or not this is so or appears to be so—that they have apparently conducted over 1,600 materials processing experiments in the Sayut 6 and 7 spacecrafts, compared to apparently three that we conducted on the Skylab mission.

And I am just wondering, is that right? Are they moving at that rate of speed in terms of what they are doing, and how many materials processing experiments has the United States conducted?

Mr. HODGE. I am not familiar with the specific numbers of what they have conducted, nor would I know how to get that information, quite frankly, or the specific numbers that we have done.

We started our materials processing program in the Skylab mission. Some of the very first work that was done, for example, on crystallography and the beginnings of the electrophoresis program were done on the Skylab back in the early 1970's.

Since that time, we have in cooperation with the Europeans built spacelab, and what we are doing is learning and understanding what is reasonable to do in that space environment, not the least of which is materials processing. A very important part of the space station program is to build the microgravity lab for the purpose of research and development, and in fact commercial production of materials that take advantage of the fact that there is a very low gravity in that environment.

They are unquestionably looking at the same science that we are, understanding the need to do research and development in the same way that we do, and are pursuing that endeavor, as we will in fact pursue.

It is very interesting as we watch our international partners, ESA and Japan, that they too are very interested in the subject of materials processing.

Senator RIEGLE. I think the American people will be surprised to learn in a bottom line sense that in effect the Russians have an 8-year lead on us in this area; that they are up there operating, and if all goes right we will be up there operating in 1994.

Just a very simple question crosses my mind and I realize the difficulty of something as elaborate as we have planned here and we are gearing for the long pull, and we have got the international consortium aspect of it and so forth, but I am wondering if that is not too long a lead time. I am wondering if we do not maybe have to think about how we shorten that gap, and not just because of the competition with the Soviet Union as an adversary, but the fact that there are important things to be learned and they are learning them, and basically we are not.

I am wondering if it is really acceptable for us to say well, if we are not up there for 8 years operating, that is just the way it is, and that is the best we can do. Or should we be thinking about finding some way to see if we cannot move up our own timetable here?

Mr. HODGE. I think to characterize the thing as a lead or a lag is not really entirely the right way to do it. It really is a question of the knowledge base as well as the capability to spend long times in orbit.

I would mention the very, very significant experiments which we have performed in the shuttle in the first 24 launches of the shuttle. We have proceeded to, in a very large direction, toward commercialization in some of these materials processing.

We have flown citizens, Walker for example, based upon the investments that have been made by McDonnell Douglas in their endeavor in the electrophoresis area. I think we are learning a great deal, albeit for a short time period, 7, 8, 9, 10 days on the Shuttle Program, but we are gaining a great deal of experience and I think that when we have our capability in orbit, we will have the knowledge base necessary to move ahead very, very rapidly.

Senator RIEGLE. But, Mr. Hodge, the problem is that we are shut down. We are not flying anything at the moment and we are not going to fly for some period of time. You said a year. I think that is unrealistically optimistic. I think it is going to be longer than that.

Everybody I talk to that has got anything to do with it tells me privately it is going to be longer than that.

We have got an enormous backlog of defense launches to go, including the ones that we are trying to launch and are exploding after being launched. So all of that has to be repeated.

What I see is the commercial side getting squeezed out. I mean if we were back in the old days, pre the shuttle explosion, we would still have a problem, I think, accommodating all of the commercial activity; but I think, too, in a sense it suggests that we can accommodate that in the meantime, absent a space station, with what we anticipate having I think is not realistic. I think we are going to find that the commercial side is going to suffer, and I am worried about that.

I am worried about the degree to which we are able to make the rate of gain, and we have got a terrible trade deficit. We have become an international debtor Nation. We are going in the hole financially at an astronomic rate. We are the third largest debtor Nation now and in 6 months we will be number one. The New York Federal Reserve Board has said that by 1990, we are going to owe the rest of the world net somewhere between $500 billion and $1 trillion, and so we have a very adverse international financial position developing now, and we need to be competitive and we need to move in terms of what can be discovered in a space environment and in a space laboratory.

Obviously, we cannot go back and undo previous decisions but it seems to me that the problem we are facing now is the Soviet Union, for example, is up there; they are very active. The Chinese have announced that they intend to go up and get started with some kind of space station. Yet the best we are able to say is that if we go as fast as we think we can go, we get all the money we think we can wisely spend and so forth, it is 1994 before we are up there.

I guess I find that a troubling set of facts. Maybe those are the inescapable bounds of the reality that we face, but you know, when you sort of take it down to a bottom line, it seems to me that we find ourselves in an adverse position and our chief adversary has moved out there and is doing things, and we are, it seems to me, quite far behind. And I would like to see if there is not some way that we can start to close that gap without having to put ourselves that far out into the future.

Maybe we are trying to do too many things. Maybe we are trying to fold too many objectives in at one time, and maybe that is costing us time. Maybe not. I just suggest that as one area to look at.

Are you prepared to say to me that at the very shortest period of time it is 1994 before we can be up there in an operational way, or is there any way to do this faster and still do it appropriately?

Mr. HODGE. With regard to the schedule that we are on, I think it would be unwise to move more rapidly than we have the knowledge to do so. I believe that many programs of the past, and not necessarily space programs, but large Government programs when they are pushed faster than is reasonable, inevitably you make mistakes, and inevitably you overrun, and they inevitably disappoint us.

I think that we have put together a very judicious program with regard to its time. I think it is appropriate for us to do this long period of definition before we bring the contractors on board. I nevertheless believe that it is necessary to bring those contractors on board this next fiscal year.

I think it would be inappropriate for us to push much faster than we are going right now, because I want to make sure that what we build we understand, we know what it can do, and that it will be reliable and safe when we put it up.

With regard to the commercial aspects of things, I share your concern. This whole question of leaderership as far as I am concerned is getting about the business of being in space. I think that we have to make being in space routine. I think we are learning about that. We have learned for the last 25 years. We are beginning to mature in that area. We have already made some endeavors, and have introduced to the Commerce Business Daily indications of the guidelines with regard to commercial participation in the construction and operation of the space station, as well as doing it through the normal procurement processes of Government.

We are working very heavily with industry, particularly the nontypical industry, the industry that has not been associated with aerospace in the past. As a matter of fact, I gave a speech at the American Chemical Society just this week on that very subject, and I see an emerging enthusiasm amongst our scientists, our research people, and our commercial people for participating in space in a way that they have never done before.

I think it is terribly important that the Nation does that, and I think the space station is a means to that end.

Senator RIEGLE. I just have to say to you, and I want to move to another area here because time is short and we have others, other members of the subcommittee and the committee that want to ask questions, but I cannot help thinking that we have been spending too much time on some wrong things, if you will, and not enough on some of the things that we should be doing, and I just obviously speak my own opinion when I say it, but we are spending a lot of money and a lot of time and a lot of resources on star wars, SDI, and just roaring ahead with the concept.

Basically more than anything else at this point a lot of scientists think it is not very smart, but something like the space station, which has enormous applied value, which ends up being available to the private sector and to citizens around the country and around the world. It seems to me that for whatever reason we are behind in that area, and I do not challenge your notion that to get there from today prudently may take as long as 1994, but that is a reflection of what our priorities have been over the last 10 years, and where we have put the emphasis.

We have spent $1 trillion on the defense budget over the last 5 years, and if you look at the space program today, I think it is in fairly sorry shape, generally speaking. We are not able to fly anything of any consequence at the moment, and we are talking about getting a space station up in 1994. Well, the Soviet Union has one up there today that is in operation, and when I add that up it leaves me with something less than a good feeling in terms of both past decisions and where we are today, and I think we have made some serious errors in national judgment in terms of where we have put our premier effort, and you know, there is really no reason for us to be laying this far behind in this area, as I think we are relative to what others are doing, but let me go to a different area, and that is the area of automation and robotics.

It is quite clear that the Congress expects the United States to develop new advanced technologies in the development of the Space Station Program, technologies that also have application here on Earth. In particular, the Congress has specified a level of effort in the area of automation and robotics, as you know, but it is important that the public know it as well.

Can you tell the subcommittee what activities are being pursued by NASA to ensure terrestrial automation and robotics application from the Space Station Program, and what is the level of effort and the level of funding being devoted to automation and robotics in the advanced technology development budget request and in the Office of Space Research and Technology budget?

Mr. HODGE. I am sure Dr. Colladay will embellish on the statements I have to make but we have worked very closely with the other associate administrators within NASA on that particular topic. Certainly the language of this committee in the last year and the discussions we have had with you and your staff people have served to heighten our awareness of that subject.

I thank you for that, because I think it has been very important that we do so. As a result of that, within the 1986 budget we in the space station out of our total $195 million are spending $11 million on the technology associated with automation and robotics. In parallel with that, OAST, the Office of Aeronautics and Space Technology, is spending $10.2 million, and so there is a total of $22 million between us on that general subject, and some additions on things associated largely with automation rather than robotics of about $5 million in the Office of Space Flight.

This is the National Space Transportation System of the OAST budget. About $4 million of the amount of money they are spending is generic experiments directly related to potential use on the space station in the future, and so we have coordinated our programs in such a way that as they do their very early research and a they do the applications research associated therewith, that it in fact is ready to come over to be developed for eventual participation in the Space Station Program.

In fiscal year 1987, we are essentially doubling that capability. It is close to $50 million within NASA as a whole. A part of that, about half of that was in the space station, and about half of that is within the Office of Aeronautics and Space Technology. We see that running at about that level, around $50 million over the next 5 years, for a total investment in this area for NASA approaching $300 million. I think that that is a responsible set of numbers. I think that it will provide some very interesting capabilities as we begin to proceed into our program, and it will provide a transfer of capability of those new things into our program as we can.

Of course, one of the fundamental premises of the design of the space station is that we design it in such a way that as new technologies become available we have already, as we say, scarred the design so that we can introduce new technologies with time. There are really three kinds that we are looking at in the space station itself. The first thing from a straight design program risk point of view, to pick those technologies which are essentially available and off the shelf for participation in the early part of the space station, I see that largely in the area of moving automation to the area of expert systems. This is largely in software programs which will allow us to do fully automatic redundancy control of systems. This is essentially state of the art right now. It involves rule-based computer programs, rather sophisticated rule-based computer programs, as a matter of fact, but that is a fundamental premise in the baseline design that we put in.

As we move forward in time, I think we can enhance that capability, particularly in the area of robotics as we go from initial telepresence, which is essentially a man in the loop using sophisticated systems in a remote location to, toward the end of the century as we understand the concepts of artificial intelligence, to actually have fully capable autonomous systems in that timeframe, and I think the amount of money that we are putting into that will lead us to that capability in the next 10 to 15 years.

Senator RIEGLE. I am going to ask some other questions for the record in this area just so that we have a full discussion in the record on this topic.

I want to ask one other question now, and that is, how would you react if the Congress suggested that a separate small business innovative research program be set up that would assume a small percentage setaside of the entire space station budget for automation and robotics?

Mr. HODGE. The whole question of the SBIR Program, I think, was a rather innovative way to go into the business of getting small people into the research game. It has been my experience in the past that very, very many of the best ideas come out of the small organizations. Large organizations tend to be bureaucratic, and it is difficult for the innovator to come forward through that, so I heartily endorse the concept of the small business innovative research program.

Now, that is already working, as I believe the number is 1¼ percent of the R&D budget of the U.S. Government. Within NASA, that program was initially managed within the Office of Aeronautics and Space Technology, and is now managed under our commercial programs organization, code I, a significant part of that. That is broken into, I think, about a dozen areas of technology, and a significant part of that is in the area of automation and robotics, and we work very closely with those people to ensure that under the umbrella of the SBI Program, that automation and robotics is a key participant. It is not clear to me that we need to have an additional budget over and above what we have talked about in that area. I think that what we need is to continue to be sure that that particular technology is pursued under that program as it presently exists.

Senator RIEGLE. Well, I appreciate your comment about the value of small entities perhaps being more able to develop some of the breakthrough ideas more readily, and I think our universities also can make an important contribution there, but I think we have to find a way to make sure that they are involved on a broad base, and of course it is like a closed loop to the extent that you do that and you foster discoveries that you might not get as quickly or even at all.

I think that tends to involve more of the economy and the society in what we are doing. I mean, I like to keep the space program on a broader base than on a narrower base. I think it is—every good reason argues for that in the end, I think, the public gaining more from the public dollars that are spent, and so I would like to see if we could not move more in that direction, and I will have some other questions for you for the record.

I have some other areas, Mr. Chairman, but I think in the interest of time right now I am going to submit those for the record. Senator Hollings had an opening statement that should be included.

Senator GORTON. We will include his opening statement in the record. I have one or two more subjects that I want to cover shortly, recognizing that we have several more witnesses. I would like to ask you about the work package. Mr. Hodge, according to your written statement, the principal outstanding issue in the Space Station Program is the restructuring of the work package.

I understand that the two options under consideration are, first, four separate and equal work packages modeled after the phase B structure, and two, one prime contractor who would oversee the entire Space Station Program and subordinate the activities of three of the field centers. Can you outline briefly the advantages and disadvantages and cost savings and costs that are likely to be realized with each of those options?

Mr. HODGE. I hope you will forgive me if I give you less than a short answer to that question, because when we were going through the early stages of the task force and putting together the Space Station Program, we believed there were two major things that we had to look at. One was the technology of the system, what it was we were going to build, what the design would be, and the second one was an examination of the management principles that we would have under those circumstances.

The history of NASA with large multicenter programs had been twofold. We had run very successfully the Apollo Program, where in fact there was a strong central capability to manage the program and a distribution of the program within multiple centers. One of the characteristics of that program was, it was fairly easy to separate the interfaces between those pieces. The interface between the Saturn V vehicle and the manned vehicles was fairly straightforward to some extent because we had duplicate systems. There was sufficient money to do that.

For example, we had a completely independent guidance system in the booster than we did in the two spacecraft on the top. That was a very successful management capability for that program. For shuttle, we took a slightly different approach, because in fact the dominant part of the Shuttle Program was the orbiter itself. It was appropriate to have the orbiter drive the overall system engineering function, and so for that program we put together the lead center concept where there was a dominant contractor, where the large part of the system engineering was done by that contractor, and that was appropriate for that program at that time.

As we looked at the space station, we saw that it was a multifunction device, and that many of those functions were associated with skills which were in various centers. For example, it was necessary, we believed, to amalgamate the cultures of the manned program and the unmanned program to get the advantages of both, and so we put the multicenter capability together.

That decision with regard to separating out the functions, working with the multicenter organization and having the lead organization which had a very strong system engineering capability was decided over a period of about a year, and in fact culminated in the meeting we had at Langley Research Center of all of the Center Directors, all of the Associate Administrators from Headquarters, the Administrator and the Deputy Administrator.

We had a final meeting on that subject and decided that in fact for the sake of phase B it was appropriate to have multiple centers involved: that that was where we had to put the capability, where the skills were within NASA: that it was extremely important that we have an overriding engineering capability to do the system engineering trades between the work packages: that it was going to be complicated because the space station does not naturally break up into easy pieces: but that for the sake of the organization in the future that was the way to go.

In some respects, that was an experiment. We had never done a phase B this way before. What we had normally done was to do phase B's where the whole program was looked at by competing organizations. For example, in the case of the shuttle there was a phase B done at Marshall and a Phase B done at Johnson, and with a single contractor in each of those, and at the end of that period we computed those two results and built the shuttle. That resulted in Johnson being the lead center, and then splitting the program up amongst multiple centers afterwards.

In the station, we felt that we wanted to test that during the phase B, and so in fact we were running phase B in a way that we thought we would run the development and operational phase of the program. I believe that has been successful. We have found out as a result of that what the difficulties associated with that are, the communication processes which are necessary between the centers. We have established now a very strong communication capability. There have been some elements of competition between the centers because we deliberately put overlap into the packages.

We are now prepared to take that overlap out. We have program agreement now to reduce or eliminate the overlap between the work packages, and we are in the process of taking that out. The final question that now remains is really whether it is appropriate to use a broad base of the agency first of all where the skills are, a fairly uniform distribution of those capabilities, a broad base of U.S. industry, broader than we used on the shuttle, and a capability within the agency to manage such a broad based capability.

Now, that is difficult. It is difficult to do it, to put that kind of management concept together. I personally believe that in the long run that we will have a more capable system that can be operated more efficiently if we amalgamate those cultures of the various centers that have participated in NASA over the past 25 years. I also believe that such a major decision with regard to precisely how we are going to head in the development phase over the next 10 years and which will in fact fundamentally affect NASA and its management principles for the next 25 or 30 years must be made by the Administrator, and it is my proposal to discuss that with him very early and to get that decision made in time to get the RFP's out.

My personal feeling is that slight modifications from what we presently have is the way to go.

Senator GORTON. Thank you. One other question only. You glanced by in a single sentence international participation and formal ratifications of your agreements with our various international partners. Can you tell me when you expect those agreements to have been ratified from a formal point of view, and particularly in connection with ESA?

Mr. HODGE. We already have formal ratification for the participation in the second half of the phase B studies, namely, the preliminary design phase with Japan and with Canada. And those two countries are proceeding with us in the preliminary design phase. In addition to that, we have program level agreement. In other words, the program manager at ESA and myself have agreed how we will proceed into the preliminary design save a total ratification from the European Council itself in its relationship with ESA. That process is presently going on within Europe right now. There are an intense set of meetings over a period of 4 or 5 weeks that began about 2 weeks ago.

I expect an answer from them, a proposal from them on how they will proceed and specifically how they will proceed during the next 9 months within the next 4 weeks.

Senator GORTON. You expect that proposal to be something you will accept?

Mr. HODGE. I expect it to be something that we will negotiate and mutually accept within a few days, yes.

Senator GORTON. We are very pleased and honored to have the ranking minority member of the subcommittee, Senator Heflin, here with us today because of his great interest in this subject. Senator, did you have any comments to make?

Senator HEFLIN. Well, thank you, Senator Gorton. I appreciate you allowing me to sit in on this. I suppose I was the first Senator that came out in support of the space station, and have advocated its moving forward as feasibly and safely and as rapidly as we can. And last week I made a speech on material processing in space, the promise and the challenge, that went into a good deal of the knowledge that Senator Riegle was asking about pertaining to the Soviets, and it might be of some benefit if it is made a part of the record by reference.

Senator GORTON. We will do that.

Senator HEFLIN. Most of my questions have been answered. I am sorry that I could not get here earlier. This other question may have been answered, is the number of orbiters that will be needed relative to the space station when it is in the construction phase and then when it is in the operation phase. Now we have three, and as I recall from earlier days, a very strong position had been taken by NASA that we could not get by with three orbiters, and at one time there was a strong feeling that there ought be a fifth orbiter, and the committee, I believe, under Senator Gorton's leadership did provide for the keeping in place of the mechanism and machinery and things for the development of the fifth orbiter as it came into effect.

If you have gone into this previously, I do not want to duplicate it, but I would be interested in relationship of the shuttle orbiters and the space station in construction and in operation and the number that would be essential for its operation.

Senator GORTON. We did go into that a little bit earlier, Senator Heflin, and that is a part of the record.

Senator HEFLIN. I do not have any other questions.

Senator GORTON. As Senator Riegle said, he has additional questions in writing, and we have a large number of additional questions in writing.

We are about to make very pivotal decisions, as you realize, Mr. Hodge, and your prompt and detailed response to those questions will be appreciated.

Mr. HODGE. Yes, sir.

Senator GORTON. Thank you very much.

Mr. HODGE. Thank you for asking us, sir.

[The statement and questions and answers follow:]

Statement of
John D. Hodge
Acting Associate Administrator for Space Station
National Aeronautics and Space Administration

Mr. Chairman and Distinguished Members of the Subcommittee:

The United States remains committed to the development of a permanently manned Space Station. Recognizing that the Space Station is essential to ensuring American leadership in space during the 1990's and beyond, President Reagan has continued to reaffirm his support of the development of the Space Station, most recently in his 1986 State of the Union address. In the decades ahead, the Space Station will enable us to continue the exploration and use of space, an enterprise in which the United States traditionally has excelled.

A Space Station will do all of these. Its value as a means to leadership is evident. The Soviet Union must certainly understand this principle, for it recently launched the core element of what it says is a modular space station intended to be permanently manned. I believe that such leadership in the years ahead must belong to the United States and that the Space Station Program upon which we've embarked is the best way to secure it. The Space Station was--and still is--the next logical step for our nation in the exploration and utilization of space.

As a permanent facility, with a crew of six to eight, the Space Station will provide enhanced capabilities in space for the United States. The Station will consist of a modular manned base as well as several unmanned free-flyers. By using both manned and unmanned systems, the Space Station will enjoy the substantial advantages offered by both modes of space flight. People will be aboard the Station base, bringing creativity, flexibility and the human capability to adjust to the unforeseen. Machines will be there too, providing reliability, precision, and the steadfast ability to perform routine and repetitive as well as high risk tasks.

The Space Station will be highly versatile. It will be a research laboratory for the conduct of science and the development of new technologies. It will be a permanent observatory enabling us to look down at the Earth and up at the stars. It will provide facilities where new products can be developed and later manufactured. The Space Station will also be a servicing facility for the maintenance and repair of satellites, a storage depot for supplies, and a place to assemble large space structures. As the Space Station evolves, it could become a transportation node, a point of check out and departure for missions to geosynchronous orbit, the planets, and beyond.

This morning I would like to review the Space Station Program with you, explain the FY 1987 Space Station budget request, and solicit your continued support.

Significant progress has been made in the two years since President Reagan directed NASA to develop the Space Station. NASA has set in motion a major technology program in support of Space Station design and operation. A special effort has been initiated to better understand the potential for utilization of automation and robotics on board the Station. Functional performance requirements have been defined to guide the definition and design of Space Station capabilities. NASA and eight industry teams have been conducting extensive system and subsystem analyses and are near completion of a Space Station baseline configuration. An acquisition strategy for development activities is being formulated and we plan to have a request for proposal completed this fall. The Space Station work package structure is under extensive review for possible realignment to facilitate management during the development phase, and I expect a decision shortly. In addition, we continue to work closely with the special advisory group of scientists established by NASA to provide counsel on how best to realize the scientific potential of the Space Station. An operations concept is being developed, and operational requirements are under review. Agreements have been reached with Canada and Japan on those elements they will carry into preliminary design while discussions with the European Space Agency (ESA) continue. In sum, NASA, industry, and the international partners have made substantial progress in defining this complex program and are now ready to begin detailed preliminary design.

The program plan calls for Space Station detailed design and hardware development to begin in FY 1987. From the start of the Space Station program, NASA has focused its efforts towards initiation of such design and development in FY 1987. Our technology program, our analysis of user requirements, our contractor system definition studies, and our negotiations with the Space Station international partners have all been directed to and based upon this schedule milestone. Industry, the user communities, and our partners abroad also have planned their own Space Station activities on the basis of a development effort beginning next year. This effort would follow the Space Station definition and preliminary design (Phase B), an effort which has provided a sound preliminary review of Space Station systems as well as a thorough understanding of the overall Space Station architecture.

Initiating Space Station development in FY 1987 is extremely important. It will signal to our international partners that the U.S. commitment to Space Station is firm and that their own budgetary and intellectual resources can safely and productively be devoted to a cooperative Space Station Program. It will signal to the U.S. private sector that future investments in commercial space activities can be planned with confidence. Initiation of Space Station hardware development will signal to U.S. industry that the program is on track and that private investment of money and talent is justified. NASA, industry, and our international partners as well as others who anticipate using the Space Station are now poised to begin actual development. Much planning has been done. Substantial resources have been utilized toward proceeding with development in FY 1987.

The Space Station Program plan integrates a wide variety of subsystem engineering, technology development, cost analyses and budgetary projections, international planning, and managerial experience into a coherent whole. The unusually extensive work done so far has made for an exceptionally strong program plan and gives me confidence that NASA and her partners will be ready to initiate development next year. The principal outstanding issue is restructuring of the work packages. As noted earlier, a decision on work packages will be made shortly. This reconfiguration of Space Station work packages will simplify interfaces, assure a strong systems engineering and integration capability and utilize the traditional strengths of the NASA field centers. The analysis we have conducted so far as part of Phase B has given us a good understanding of technical Space Station issues. It has also given us a better understanding of managerial issues. In each case, as a result of increased understanding, we are making adjustments. Such adjustments, both technical and organizational, are typical in a program of this scope. By making them now, before we are engaged in detailed design and development and by basing them upon our Phase B experience, we will minimize the likelihood of having to make changes later, during development when such changes could be extremely unsettling and very costly.

The Space Station Program continues to target 1994 as the time when an orbital capability is achieved. Our definition analysis confirms that such a date is realistic. It also confirms our belief that a useful Space Station can be developed within the constrained budgetary outlook facing both NASA and the nation. During our period of Space Station definition and preliminary design, we are carefully examining the question of Space Station cost and are defining a program to fit within current budget projections. This program assumes that there will be one U.S. laboratory module, primarily outfitted for materials research. The international partners are also studying elements which would be an integral part of the Space Station. Of course, the Station will be designed from the start to be able to evolve over time so that greater capabilities could be realized in the future.

Conceived with a Space Station in mind, the Space Shuttle will be the principal means of transportation to and from the Space Station. An efficient space transportation system is essential to realizing the enormous potential of the Space Station. Beginning in the 1990's, it will lift the Space Station elements into orbit and be used in the assembly and check out of the Station. It is envisioned that the Space Shuttle will bring crews, supplies, and equipment to the Station. Equally important, is the Shuttle's unique capability to meet the Station's requirement of bringing payloads back to Earth. Return flights to Earth will carry new commercial and scientific materials made in space, at the Space Station. Moreover, equipment and crews that have been in space for several months will be returned to Earth. Only the Space Shuttle can do this. Current U.S. expendable launch vehicles do not have a return capability. Neither does the European Ariane vehicle. The Space Shuttle is the foundation upon which the very concept of a permanently manned Space Station is built.

The loss of Challenger makes us all acutely aware of safety and of the absolute requirement that we ensure the safety of both our flight and launch crews. The Space Station will be a safe and reliable system. All of us at NASA and in industry are committed to developing and operating such a system. I have no doubt that we can do so. In order to reemphasize the importance of safety within the Space Station Program, I will be establishing shortly a Space Station Safety Panel which will report to the Associate Administrator for the Office of Space Station. This will insure that our planning fully and properly accounts for safety issues. These issues are different from what we have encountered in the past. As a permanent facility, and as one whose flight characteristics are relatively benign, the Space Station poses a unique set of requirements. I expect the panel will examine a number of these areas, including, for example, the subject of crew rescue and the nature and content of our rescue philosophy. While we cannot entirely eliminate personal risk from the Space Station, we can minimize it and understand it fully. I expect the Space Station Safety Panel to help us do both.

International participation is an important dimension of the Space Station Program. Canada, ESA, and Japan have responded to President Reagan's invitation to join the Space Station endeavor. Later in this statement, I will review the nature and details of the current agreements we have with these countries. International cooperation will be extremely beneficial to the Space Station Program. We will have a more capable Space Station as a result, and we will share developmental and operational costs with the partners.

Another important dimension of the Space Station Program has been the emphasis given to understanding and incorporating requirements of the user communities. NASA, within the boundaries of technology and resources, is committed to developing a Space Station that serves science, commerce, and technology. From the beginning our focus has been to make effective Station utilization a high priority of our program. In this regard, we have been greatly assisted by the work of the Task Force on the Scientific Utilization of the Space Station, chaired by Dr. Peter Banks of Stanford University. Dr. Banks and his colleagues have provided sound advice and numerous recommendations on how the Space Station and its free-flying platforms can best serve the many demands of space science. It is their view that one of the most important considerations is to deliver a useful facility on the currently envisioned schedule, even if that facility is somewhat less capable than originally conceived. Associated with this consideration, it is equally important, from the Task Force's perspective, that the agency enunciate and implement a plan for evolution of Station capability beyond that which will be available initially.

Our total budget request for Space Station for FY 1987 is $410 million. This level of funding will allow us to complete the definition and preliminary design effort for the initial Space Station as well as initiate development activities. Of this amount, $15 million is for Utilization, $83 million is for Advanced Development, $88 million is for Program Management and Integration, $17 million is for Operational Readiness, $57 million is for System Definition, and $150 million is for System Development. Attached to this statement is a chart that summarizes our request for the FY 1987 budget and also shows funding which was previously approved for our definition activities.

Mr. Chairman, at this time I will describe the major elements of our budget request for FY 1987.

Utilization

In FY 1987, a total of $15 million is requested for the continued definition of Space Station utilization requirements. These requirements cover both the manned base and the unmanned, free-flying Space Station platforms. The Utilization Program has, over the past three years, worked closely with several hundred potential commercial, technology, and science and applications users to assure that their wide and varied requirements have been considered during the definition and preliminary design activities. During the past year, these user requirements have been integrated into a functional requirements envelope which has guided the definition studies. The functional requirements envelope is now evolving into the Station performance envelope which will include both specific user requirements and general requirements for basic Station-keeping activities. This performance envelope will serve as a baseline for the preliminary design efforts. The incorporation of these requirements into the Space Station design and development will accommodate a variety of users.

Space science activities and operational applications continue to provide a strong set of demands on Space Station capabilities. The Office of Space Science and Applications has refined a set of intended uses of both the manned element and polar and co-orbiting platforms as part of its normal planning activities. We have made progress in understanding the needs of our international partners and other U.S. governmental agencies, and we have been using such requirements in the definition studies.

The servicing capabilities of the Space Station will be one of its most valuable functions giving us the capability to make repairs and improvements on orbit, thus extending the life of specific space assets. During FY 1986 and FY 1987, we will continue to define the servicing concepts and standards that can be implemented by both Station designers and the user payload communities. We will continue to define both specific servicing activities that can best be conducted from the Space Station and the appropriate role of robotics in facilitating the optimal mix of both humans and machines.

We continue to interact with both the Task Force on the Scientific Uses of the Space Station and the Space Science Board of the National Research Council. The Board is completing a two-year study of the future directions for space science in the late 1990's and early 21st century. Results from their study will form part of the input for our considerations on Space Station evolution. The Task Force meets regularly, has had two major summer workshops, and has presented its workshop recommendations to the agency. Earlier this year we submitted our assessment of the 1984 workshop recommendations to the full Committee on Commerce, Science and Transportation.

A major NASA goal is to expand private sector investment and involvement in civil space activities. We continue to work closely with NASA's Office of Commercial Programs to realize this goal within the Space Station Program and to seek out those commercial enterprises that might profit from using the Space Station. During the past 18 months, we supported activities which introduced over one hundred companies to the commercial potential of the Space Station. As a result some two dozen of these companies are currently developing commercial space experiment concepts or are pursuing joint agreements with NASA for commercial ventures. Several major Fortune 500 corporations are funding research to assure readiness to capitalize on Space Station facilities.

In addition to promoting commercial use of the Space Station, we have initiated activities to encourage private sector participation as builders or operators of Space Station systems and services. Entrepreneurs with private funds are encouraged to consider such participation. "Draft NASA Guidelines for United States Commercial Enterprises for Space Station Development and Operation" were released for industry review in November 1985. These guidelines have sparked considerable interest in the private sector and will serve as the foundation for a formal set of policy guidelines to be issued by NASA this spring. In addition, we are currently identifying Space Station elements we believe to be suitable for commercial development and operation. Our Memorandum of Understanding with Space Industries, Inc., signed on August 20, 1985, on the Industrial Space Facility (ISF) and docking system is a specific example of cooperation in the possible commercial development of space hardware. The Space Station Program and Space Industries, Inc. are exchanging information relating to Space Station and ISF design activities during the definition phase of the program.

During the past year, the utilization program continued efforts to build a technology development user constituency in cooperation with the Office of Aeronautics and Space Technology (OAST). OAST's recent "In-Space Research Technology and Engineering Workshop" identified a broad menu of technology development experiment concepts for Space Station utilization. These new "model experiments" have been integrated into the Space Station user data base and the Space Station definition and preliminary design process. The Space Station clearly will represent a unique capability for developing new technologies. The technology community continues to plan for use of the Space Station during its assembly phase as a technology test bed representing generic systems, (e.g., structures and control systems) and to instrument those systems to complement the Station check out and verification phase. This test bed approach will provide early research use of the Space Station and provide a reference for future technology activities.

During FY 1987, we will continue to assure that user activities which might be enabled or enhanced by the Space Station are identified, and we will continue to work with users to assure that we properly understand their requirements and are properly translating these requirements into the design of the Space

Station. Specific decisions thus far which have been driven by the user community are the laboratory module internal pressure and composition, and the location of the laboratory module with respect to the system center of mass, module length, and platform design. Through user interaction, the utilization program will continue to insure an optimized international facility which will provide a unique environment to a diverse research community.

Advanced Development Program

The objective of the Advanced Development Program is to ensure that the technology which is needed for the Space Station is available when required. The program is structured to demonstrate the feasibility of new technology and to define the cost and schedule associated with its use. In FY 1986 technology development activities are being conducted in 14 technology categories. Each task is targeted toward the development of specific hardware or software products for consideration for inclusion in the design of the initial Space Station. A total of $83 million is being requested for the Advanced Development Program in FY 1987 to enable this smooth transition of selected technology elements into the development phase. In FY 1987, we will concentrate on maturing the most promising technologies and phase down activities in those technologies where the risks are too high for inclusion in the initial Space Station.

For example, automation and robotics has the potential to materially improve the human productivity aboard the Space Station. This fiscal year we are in the process of identifying promising applications of automation and robotics for the initial Station. We are also studying longer range applications, life-cycle cost estimates of applying these technologies, and detailed design provisions that would be necessary to eventually accommodate these evolutionary concepts. In FY 1987 the development of advanced applications of automation and robotics will include the use of expert systems and spaceborne symbolic processors for fault diagnosis and fault recovery. Applications will also include the investigation of tactile sensors for force feedback; automation of guidance, navigation and control functions; and management of redundant subsystems. We have also reported to the full Committee our implementation planning activities in response to the 1985 recommendations of the Advanced Technology Advisory Committee concerning automation and robotics applications for the Space Station Program.

As directed by the Congress, we will complete the design of a test bed for a flight telerobotic system to be used for servicing spacecraft brought to the Space Station. This system will be the nucleus of a smart front end that will be used on the Orbital Maneuvering Vehicle for precision tasks required in the in-situ servicing of platforms and other spacecraft.

Another prime technology task in the Advanced Development Program is the development of solar dynamic power generation for use on the Station. Solar dynamic systems are attractive because they will enable increases to be made to the power system without the penalty of increased aerodynamic drag caused by additional larger solar arrays. To overcome this additional aerodynamic drag, logistics and propulsion costs would increase. Such systems will also benefit users by allowing less obstructed viewing. Several critical elements of a spaceborne solar dynamic system have been developed in FY 1986.

In FY 1986, we completed trade studies of four different techniques for structural trusses. In parallel with these studies, we participated in and supported the EASE/ACCESS space construction experiment conducted by the Office of Space Flight. This flight experiment provided invaluable data, and coupled with the other structures studies, led us to select an erectable truss approach for assembly of the initial Space Station. In FY 1987 we will build prototype erectable trusses for evaluation.

Several other elements of the Advanced Development Program were scheduled for flight tests aboard the Shuttle within the next few years. These flight tests will be rescheduled when the Shuttle again becomes operational. We anticipate no difficulty in scheduling these experiments as they are small, and as before, will most likely be used to complete various Shuttle manifests as accommodations permit.

Human productivity is a another thrust of the Advanced Development Program and the Space Station definition and preliminary design process. An example of technology development in this area is the improvement of the extra-vehicular maneuvering unit (or space suit) to enable crew members to operate more efficiently outside the pressurized modules.

In FY 1987, in addition to continuing to improve the space suit, we will build and test a full-sized hatch and rotary joint mechanism. Subsystem testing will be conducted on thermal control systems, data management systems, attitude control systems, mechanisms, and power systems. We will also begin preparation of a flight experiment to investigate the effects of atomic oxygen on Space Station materials.

Program Management and Integration

Through our Program Management and Integration effort we support the management of the overall Space Station Program and perform systems engineering and integration (SE&I) activities. Support efforts include the Technical and Management Information System (TMIS) and the Software Support Environment (SSE). A total of $88 million is requested for these various Project Management and Integration activities in FY 1987.

SE&I efforts are perhaps the most difficult engineering challenge in the Space Station Program. These efforts are carried out by NASA and involve the integration of information obtained from both agency and contractor studies leading to the establishment of a baseline configuration which meets performance and safety requirements.

Major components of SE&I are the conduct of trade studies converging to design solutions with the best balance between cost, risk, and performance. SE&I activities in FY 1986 include selection of options for the initial baseline system configuration, and the definition of interfaces for major Space Station elements. During the latter half of FY 1986 and into FY 1987, SE&I activities will concentrate on producing a preliminary design and on finalizing those technical requirements that will govern the subsequent detailed design and development of the Space Station.

Because the Space Station Program involves a number of NASA installations, prime contractors, a multitude of subcontractors, and hundreds of potential users, in addition to foreign space agencies which may have similar complicated interfaces, a system is needed to facilitate both technical and managerial communications, including the intricate SE&I process. TMIS will be such a system. With proper design, maintenance, and utilization, TMIS will help minimize Space Station design and development costs throughout government and industry by increasing productivity and streamlining such processes as information exchange, data acquisition, program and data base management, and configuration control. Thus, it is vital that TMIS be designed, acquired, and be operating as soon as possible so that it will have timely and maximum impact upon program resources and management.

TMIS will consist of a sophisticated network of primarily off-the-shelf data processing equipment and software. Specific features of the system will include computer-aided-engineering and computer-aided-design functions, engineering data base management, project scheduling and management, documentation interchange, budget planning, and electronic mail. The TMIS user community will include all NASA personnel involved in the Space Station Program, contractor personnel, with separate links to the international partners. Within the TMIS network, any terminal or workstation will be able to access most applications on the host computers.

In FY 1985 we initiated the TMIS project, developed a master plan and schedule, and procured some initial, but limited, hardware and software elements. These currently functioning elements are capable of supporting such activities as budget planning, scheduling, and some data base management. Limited computer-aided-design and computer-aided-engineering capabilities are also available within the current architecture, but a standardization of graphics communications is needed to allow complete system networking of graphics and data base management capabilities. A multi-year contract will be awarded for the detailed design, acquisition, and maintenance of the TMIS system including the architecture, standardization, installation, and operation. Over the contract performance period, system capabilities will be added and enhanced, including provisions for parametric cost and schedule estimating, data dictionaries, and engineering data transfers.

The SSE is considered critical to the success of the Space Station Program. Its capabilities will assure the commonality necessary for software and system integration and long term maintenance across the program. The Software Support Environment (SSE) is the integrated set of tools, policies, procedures, training, and system software that will be used to develop, acquire, integrate, check out, and maintain all Space Station Program operating software on board the Station as well as the ground.

The SSE will be constructed around a small core of software languages. The primary language is planned to be Ada, but other languages will also be supported as we intend to maximize the use of existing software. The SSE will be extremely important to Space Station users as it will provide a standardized capability for preparation of their payloads and integration into the data systems.

Studies to date have resulted in the specification of the overall SSE concept and top level requirements and design. Next we will competitively procure the services of industry for the detailed design and delivery of the SSE in an incremental fashion. The deliveries must be timed to provide the types of tools and procedures needed for each stage of the Space Station development process. Thus, the SSE procurement must precede development activities. We plan to release the SSE request for proposal in June 1986 with a contract start date approximately six months later. In FY 1987 we will complete definition and begin development of the SSE. This effort will constitute the first major portion of the development phase of the Space Station Program.

Operational Readiness

During the definition and development phases, the function of the Operational Readiness effort is to produce the plans, procedures, systems, and ground support equipment that ensure user-responsive, cost-effective application of Space Station capabilities. It is imperative that we focus on the cost, ease, and utility of operation of the Space Station while we design and develop it.

This focus will be a key to accomplishing affordability. The life-cycle cost of the Station, including operations costs, must be held to a minimum consistent with safety and utility. It is also recognized that we must involve the users of the Space Station at all levels of our management and operations, ranging from strategic and policy matters to daily operations.

In December 1985, we formally reported our planning activities for life-cycle cost management to the full Committee on Science and Technology. Our report, "Operations Cost Management," described how we are developing the methodology and tools which will enable us to evaluate the effect of engineering options on long-term operations costs. To do this, an operations concept is being developed that allows the user a maximum degree of autonomy and provides a structure within which users are directly involved with the tasks of resource allocation and utilization. This concept will form the foundation for the development of our operations requirements and plans for the program. Review of this concept is deliberate and thorough, and we are also obtaining the input of our international partners. We have also been formulating life-cycle cost management techniques which will be complementary to the operations concept.

A major focus for the Operational Readiness effort in FY 1986 has been to devise mechanisms to allow us to evaluate various options for user requirements by considering their effects on the overall life-cycle cost of the program. Numerous other studies are also underway, including studies on the application of automation and robotics to operations; integrated logistics; transportation and manifesting; cost estimation; and real-time data management.

In FY 1987, we are requesting $17 million for Operational Readiness. During FY 1987, our planning will transition to the specification of requirements as preliminary design and development begin. The bulk of our FY 1987 funding request will be used for specifying logistics requirements, particularly support equipment, ground systems, and long lead time spares. Such requirements will constitute the long lead time items needed for enabling the program to perform its space systems and user operations support functions. In FY 1987, support center and pre-launch processing requirements will be defined and preliminary design will begin. Facility outfitting will also be planned.

In FY 1987 we also intend to produce an operations plan which will be the next level of detail in moving from the conceptual phase toward a detailed operations methodology. The Operations Cost Management Plan will be refined and implemented, allowing us control over both the ultimate operations cost of the program and the initial cost of development.

Logistics support requirements for the Space Station Program will exceed those of any prior NASA program, thus requiring that an integrated logistics support system be developed. In order to control logistics costs and avoid duplication of capability, the program will create an activity which is integrated across NASA, other agencies, and with participating nations. It is vital that an integrated logistics process and support system be defined and implemented early in the program so that it can influence design, operability and life-cycle costs.

System Definition

In April 1985, the Space Station system definition process was begun with the competitive award of contracts to eight aerospace industry teams. The process, now past its half way point, has involved both the users and international partners. Through trade studies and analyses, NASA and the industry teams have examined the relative merits of various design options. As a result of the recent system requirements review, we now have a recommended baseline configuration. When a final configuration is selected, the result will be a Space Station configuration which maximizes performance, safety, and functionality requirements within a cost-constrained envelope and a realistic schedule.

The significant features of a Space Station have emerged. Our original concept of a power tower structure has evolved into a dual keel structure which will better satisfy user requirements for microgravity in the pressurized modules and provide for accommodation of additional payloads outside the pressurized modules. The length of the U.S. modules has been expanded to be approximately 44 feet to provide more volume for experiments and manufacturing activities. We have decided to use, for the first time in any U.S. manned space system, a closed environmental control and life support system in which oxygen and water are recycled and only nitrogen and food are resupplied. This system will enable us to resupply the Space Station with these items as few as four times per year.

The baseline configuration will also incorporate a module pressure and composition that simulates sea level Earth atmospheric conditions. The choice of this atmosphere minimizes flammability problems and eases constraints on the types of materials that can be used within the pressurized modules. This Earth-normal atmospheric pressure and composition will greatly facilitate the conduct of scientific and commercial activities within the pressurized module by allowing us to capitalize on the extensive baseline data already developed on Earth as well as allowing us to use existing types of laboratory equipment.

We have decided to assemble and operate the Space Station at 220 and 250 nautical miles respectively, lower than the 270 nautical mile orbit originally planned. This strategy is intended to lower launch costs by enabling the delivery of heavier payloads with each Shuttle flight to the Station for only a slight increase in Station propellant cost to maintain the lower orbit.

The recommended baseline includes two U.S. modules: one laboratory module, outfitted primarily for materials research and development, but capable of supporting other science experiments, and one habitation module. Other decisions which have been made during the definition process include a hybrid power generation system which will consist of both photovoltaic and solar dynamic components. In conjunction with these recommendations and the anticipated international hardware contributions, an assembly sequence was also selected. Safe haven facilities, to be used in the event of an emergency, have been retained as an important and necessary feature of the Space Station.

Over the next few weeks, these and other options which have resulted from the very thorough definition studies will be examined and will result in the selection of a complete baseline configuration. Also in the process of being finalized is an examination of the merits of deploying a Space Station initially in a man-tended mode which would then evolve to the permanently manned Station. Results of this study have been considered in our planning thus far and will continue to be considered in the formal selection process of a baseline configuration and assembly sequence.

Based upon the selection of a configuration which will be made shortly, we will initiate and establish the preliminary design for the initial Station. During the balance of this fiscal year and continuing into the first quarter of FY 1987, we will establish the sequential logic for the design of the Space Station. We will fine tune the appropriate sequence for integrated assembly and check out of Station components. Also during preliminary design, we will determine the optimum strategy for implementing the hybrid power system while considering Shuttle payload capacity, early Space Station power needs, and the assembly sequence. We will also develop the required interface documentation, including integration with the Shuttle program, and integration of the operations concept into the overall program. Maintainability and commonality requirements will also be established.

We are requesting $57 million in FY 1987 to complete this phase. The task is proceeding extremely well; we have conducted a thorough, systematic review of Space Station requirements and definition; and we will be ready to begin detailed design and development in the third quarter of FY 1987.

System Development

NASA and its industrial teams are currently involved in a particularly rigorous definition and preliminary design study. These definition efforts represent a considerable investment of both public and international funds. Initiation of Space Station development will help ensure a smooth transition between the definition and development phases for the various government and industry teams. Proceeding with Space Station development in FY 1987 is necessary to reinforce the commitment to U.S. leadership in the 1990's and beyond and to signal America's intention to look confidently to the future.

The current definition studies are providing end item specifications and detailed procedures which will form the foundation of the development phase. The systems development phase will begin with detailed design, progress through the manufacturing of hardware, test, verification, and launch, and conclude with on orbit assembly and check out.

The design, development, and implementation phase of the Space Station Program (Phase C/D) is planned to begin in 1987. The first major milestone will be the preliminary design review. The design of long lead items must be completed early so that they can be developed, tested, and integrated into the overall configuration in time to assure meeting our 1994 goal.

We will develop estimates for the manufacturing and assembly flows so that we can develop the overall integration flow. The NASA, industry, and international team will be greatly assisted in designing the Space Station and developing the integration flows by the TMIS computerized management information system. TMIS will permit an efficient and automated interchange of technical and management process information. Since it will provide computer-aided design and engineering support during system development, it will enable a faster, more efficient resolution of design issues and implementation of changes than has previously been possible in NASA programs.

Early in Phase C/D, we will devise a total vehicle verification plan. This plan will integrate all the subsystem and system verification requirements and will provide a methodical system for insuring that all aspects of the total system are properly integrated and tested.

Prior to the preliminary design review, the feasibility of many of the technology development items in the Advanced Development Program should be evident. Through breadboard and brassboard testing, as well as flight experiments on the Shuttle, we will be able to make informed and confident decisions on the optimum systems configurations. In addition, we will have established design allocations for all on board Space Station resources, including power, extra-vehicular activity, weight, and mass properties. The next important milestone, the critical design review, will mark the beginning of Space Station manufacture, test, integration, assembly, and verification.

In the past several months, we have devoted considerable attention to acquisition strategy and procurement planning for Space Station detailed design and development. A strong emphasis of the major Space Station element design, development, test and engineering contracts will be to emphasize the achievement of both technical and safety goals within planned costs. All major procurements will be open competition and are expected to contain features to motivate the suppliers to avoid cost growth and to exercise schedule discipline. Key milestones through the design, fabrication, qualification, outfitting, and delivery sequence may be incentivized. Technical change discipline is also essential if program cost escalation is to be avoided.

Current acquisition planning requires selection by NASA of the configuration baseline shortly after the system requirements review. Upon completion of this major milestone, center preparation of project plans and the requests for proposals are planned to meet the target date for release for bid in October 1986. We are requesting $150 million in FY 1987 to initiate the development phase which will start with the detailed design of systems and subsystems leading to the preliminary design review milestone. Some of these long lead items include development of software standards and protocols, the common module structure, critical components of the environmental control and life support system, and certain components of the power system such as various high temperature devices. We will establish hardware standards and begin applying software standards and protocols, and identify long lead items. Early in the development phase the contractors will use government furnished test beds to assess, validate, and conduct proof of concept tests on prototype hardware in support of detailed design.

International Activities

The international dimension of the Space Station Program is extremely important. Our international partners will add significantly to the capabilities of the Station and will share in its operational costs.

In response to President Reagan's 1984 invitation for U.S. friends and allies to join the Space Station Program, Canada, Japan, and the European Space Agency (ESA), the latter representing ten countries of Western Europe, have conducted considerable analysis of both user requirements and systems definition. Like NASA, they too are now poised to begin hardware development. Our three international partners are now conducting definition and preliminary design studies in parallel with our own studies. Last December, each of the partners proposed to study the provision of specific hardware elements for the Station. NASA has responded by indicating which of the proposed elements complement our plans for the utilization of the Space Station, particularly during initial operations.

In accordance with the provisions of our Phase B Memoranda of Understanding, we have reached firm agreements with both Japan and Canada for the elements which they will carry into preliminary design. Japan will study a pressurized laboratory module with a local manipulator and an external attached workdeck for mounting small to medium-sized payloads requiring exposure to the space environment. This laboratory will be equipped to accommodate general scientific and technology development research activities and control consoles for monitoring activities at other locations on the Space Station structure. Japan will also study a logistics module for use in resupplying experiments.

Canada's preliminary design will focus on a mobile servicing center which will include the Space Station Remote Manipulator System, a base structure which interfaces with translation capability to be provided by NASA, end effectors, servicing tools, control stations, and special purpose dextrous manipulators. Such a hardware complement would be used to help assemble and maintain the Space Station, as well as help perform maintenance on instruments and experiments mounted on the Station structure. Canada will also perform preliminary design of a maintenance depot for the mobile servicing center which could be used for repair and maintenance and for storing spare parts.

Discussions with ESA on the elements which they will carry into preliminary design are continuing. The major potential elements include a pressurized laboratory module for life science experiments and materials experiments, a polar platform, and a co-orbiting platform.

To achieve maximum Space Station capability at the lowest cost and with the minimum amount of duplication of effort and resources, we have proposed to our international partners the concept of functional allocation relative to the design, outfitting, and use of the Station. Under this concept, primary areas of the Station will be equipped to optimally perform research for a given function, thereby minimizing duplication of facilities and enhancing the overall capabilities of the initial Space Station to satisfy the maximum range of user needs. In applying this concept, it is essential that all partners have access to all Space Station facilities, both the manned base and the unmanned platforms. Each partner is being encouraged to provide generic research equipment for use by all. The point we are emphasizing with this concept is a simple one: the Space Station, its platforms, manned base, and logistics complex, is a single system. There is to be one Space Station. We are not going to build a facility consisting of separate national enclaves.

In the months following the baselining of the configuration which includes the international elements, negotiations will begin in conjunction with the Department of State, on Memoranda of Understanding between NASA and its Space Station partners for the design, development, and operational phases. Our objective is to have these Memoranda of Understanding concluded prior to the initiation of our own development contracts in May 1987 so that international hardware development can be initiated on schedules compatible with those of the United States. Appropriate government-to-government agreements will also be negotiated with the U.S. Department of State having the lead role in developing these necessary agreements. NASA will, of course, participate heavily in the negotiations.

These agreements will address more than those decisions on which elements of the Space Station each partner will provide. These new agreements will establish long term partnerships to jointly design, develop, operate, and use the Station over several decades of operation while looking forward to even greater cooperative space ventures in the future. Successful negotiation of these agreements will constitute a major milestone for the Space Station Program this year. As we negotiate these agreements with our Space Station partners, we will keep the Subcommittee informed of these activities and of the progress we are making.

Conclusion

The Space Station continues to be the next logical step in this nation's efforts to explore and use the environment of space. It represents a commitment by the United States to leadership in civil space activities. By providing a new capability for the conduct of science in space, the development of new technologies, and the promotion of business, the Space Station will retain American preeminence in space into the next century. As we reexamine the Space Shuttle program, we must at the same time look beyond the Challenger accident. Space has been, and with the Shuttle and the Space Station it will continue to be, an arena of unparalleled American success. In space we have gained new knowledge and new technologies. The space program has provided a new dimension to the human adventure and it has instilled in Americans a deep sense of pride. In the 1990's the Space Station will continue and enhance this legacy. As a facility and laboratory in space, its value is extremely practical yet powerfully symbolic. As a program it is about to move into a critical stage. Now more than ever, the Space Station is important to our future and we must move forward as planned.

OFFICE OF SPACE STATION
FY 1987 REQUEST BUDGET
TOTAL PROGRAM
(Real Year Dollars In Millions)

	FY 1985	FY 1986		FY 1987
		P.L. 99-160	G-R-H	
UTILIZATION	9.3	11.1	10.6	15.0
ADVANCED DEVELOPMENT	50.1	70.8	66.9	83.0
PROGRAM MANAGEMENT/ INTEGRATION	35.7	57.8	53.7	88.0
OPERATIONAL READINESS	2.9	5.3	5.2	17.0
SYSTEM DEFINITION	57.5	60.0	58.9	57.0
TOTAL DEFINITION REQUEST	155.5	205.0	195.3	260.0
SYSTEM DEVELOPMENT	--	--	--	150.0
TOTAL BUDGET REQUEST	155.5	205.0	195.3	410.0

QUESTIONS OF SENATOR GORTON AND THE ANSWERS

Question 1: What is the projected funding profile for the space station program through 1994? What success is NASA having in designing the space station to a budget of $8 billion?

Answer 1: The Systems Requirement Review, conducted in March 1986, concluded an 11-month period of definition of content and cost and resulted in a recommended Space Station baseline configuration that was derived from the reference configuration. This marked the beginning of the preliminary design and detailed cost estimation in preparation for hardware development (Phase C/D) of the Space Station Program. Adjustments are being made in the development approach and content of the baseline configuration to ensure that it fits within the $8 billion (FY 1984 dollars) cost envelope.

Use of conservative technologies and engineering approaches to subsystem design and the reduction of the number of U.S. modules, providing approximately the same volume of the original plan of four U.S. pressurized modules with two large modules, has resulted in a configuration that is affordable and supports meaningful user activities. This configuration assumes major elements to be developed and built by the international participants.

Current estimates of the funding that will be available during the development phase of the Space Station Program have led us to develop a plan which, by changing the original planning schedule, will allow us to meet the President's goal to provide a permanently manned, useful capability within a decade. This capability will be somewhat less than that of the baseline, but it will evolve to that baseline. The following projections are consistent with the NASA five year budget estimate.

	DEFINITION		DEVELOPMENT		
	(Real Year $ in Millions)				
FY 1985	155.5		---		
FY 1986	195.3		---		
FY 1987	260.0		150.0		
FY 1988	---		1000.0		
FY 1989	---		1800.0		
FY 1990	---		1950.0		
FY 1991	---		2170.0		
BALANCE	---		4470.0		
TOTAL:	610.8	+	11540.0	=	12150.8*

* This equates to approximately $8 billion in FY 1984$.

Question 2: How will the anticipated backlog of payloads and missions affect NASA's ability to have an initial orbital capability by 1994?

Answer 2: The Space Transportation System is expected to support the Space Station's initial orbital requirements as scheduled.

Question 3: How many Shuttle flights will be required to establish an initial orbital capability and an initial operating capability, and what is the expected timing of both of these capabilities? Under this scenario, when would the international elements be deployed?

Answer 3: The number of flights is dependent upon the Space Station configuration and the assembly sequence which, in turn, is sensitive to a number of factors including user capability, permanently-manned capability, international capability, and a full baseline configuration capability. We have selected a launch sequence for planning purposes that emphasizes a useful man-tended capability as early as possible, in 1993, to be followed soon thereafter by an initial orbital capability for permanently-manned operations by 1994, consistent with the Presidential mandate to establish a permanently manned Space Station within a decade. We believe we can achieve this permanently manned capability with nine STS missions.

The completion of the full baseline configuration requires the assembly of additional U.S. and international elements to the Space Station. The assembly rate will also be dependent upon user requirements and associated logistics missions. The number of STS missions in this timeframe is still being assessed, but present planning suggests that assembly of the baseline configuration could be completed with an additional nine STS missions totalling 18 missions, exclusive of logistics missions. This capability will be dependent upon funding availability but could be achieved by 1995 or 1996. The international modules would be deployed subsequent to the ninth flight in early to mid-1994.

Question 4: To what extent will the suspension of Shuttle flights and our future constrained launch capability retard the development of the technologies of space station-user groups--will the application of these technologies lag behind the initial orbital capability of the space station?

Answer 4: The suspended and future constrained Shuttle launch capability may slow the development cycle of some of the early Shuttle users. Progression through the various stages of basic research, development, testing, proof of concept, prototyping, or pilot production requires a number of flight opportunities. We do, however, anticipate that the user communities, at varying stages in their maturity cycles, will be ready to conduct useful, productive activities on the early Space Station.

Question 5: How does NASA's present space station assembly sequence accommodate a man-tended capability and a permanently manned capability? To what extent does the assembly sequence differ for a man-tended capability compared to the assembly sequence for a permanently manned capability?

Answer 5: The current planning assembly sequence places the first pressurized module, the U.S. laboratory module, in orbit at the sixth launch. At this point enough of the other Space Station systems are in place to permit limited, man-tended user operations, such as servicing attached payloads, while the rest of the Station is being assembled. The second pressurized module, providing the habitability features of the Space Station and thus enabling permanent manning, is presently planned to be placed in orbit on the eighth launch.

Should it be necessary to operate in the man-tended mode for any length of time, the launch of some elements of the Space Station would be deferred and other payloads might be substituted. If this decision is made at a later date, resources would be wasted since payloads demanding a permanent presence in space will be under construction and the development of these payloads would be required to be altered or terminated.

Question 6: I understand that NASA is about to complete its analysis comparing a man-tended facility to a permanently-manned facility. Could you tell the subcommittee some of the conclusions you have reached in this analysis and the assumption used in your analysis?

Answer 6: Assumptions used in this analysis were as follows:

The design of a man-tended station was approached as a phase in the development of the permanently manned Space Station;

The design of the man-tended station includes scarring for evolution to the permanently manned capability and scarring for growth remains unaffected;

Platforms were retained as integral parts of a man-tended station;

The schedule of the first launch is the same as that for the baseline program;

The same state-of-the-art was assumed for automation and robotics as for the permanently manned Space Station;

The definitive cost comparisons were based on the President's FY 1987 budget request.

The following major conclusions were reached:

A man-tended space station, as an interim step to the permanently manned Space Station, is technically feasible;

Certain user operations, such as servicing attached payloads, could be performed in this mode; most experiments involving humans and animals would have to be postponed until permanently manned capability was achieved;

Some initial costs could be deferred but the total cost of the development of the permanently manned Space Station would be considerably higher if operated in the man-tended mode for some years.

Question 7: How is the man-tended capability deficient compared to a permanently manned capability, and are there any advantages to operating in a man-tended mode for some time before moving into a permanently-manned mode?

Answer 7: The major deficiency of the man-tended capability lies in its negative impact on large segments of the user community. Most experiments scheduled for the manned core of the Space Station are crew-time intensive and cannot be accommodated during the short visits of the Shuttle. These include all life sciences experiments involving humans and animals, which are vital to advancing our knowledge about long-duration space flight and most materials research experiments that would lay the groundwork for future commercial utilization of space. There are no apparent advantages in operating in a man-tended mode, other than the possibility of deferring some costs.

Question 8: What are the cost-differentials in the two concepts? What cost savings or deferrals are realized in either of the two concepts, and likewise, what cost accruals, or penalties, are realized in either concept?

Answer 8: Calculated in FY 1984 dollars, based on the President's FY 1987 budget request, and assuming man-tended operation for three years, and that the U.S. provide a mobile servicing center, $284 million could be deferred through FY 1991. The total development cost of the permanently manned Space Station, if this man-tended phase were added, would be about $1 billion more through FY 1987 with a three year delay than the $8 billion needed to complete the permanently manned facility without delay.

Question 9: How would international participation in the program be affected if NASA were to delay the implementation of the permanently-manned capability?

Answer 9: The President has invited our friends and allies to participate in a permanently manned Space Station. While we have informed our international partners about our studies involving the man-tended space station, we have not asked them to contribute to the study.

Prior to Phase B, our three potential partners conducted studies on potential Space Station utilization activities that they would like to undertake. Their studies, like the U.S. studies, confirmed the need for a permanently manned Space Station. Based on these studies, the potential partners proposed to study relevant hardware elements during the Phase B. Two of NASA's potential partners, Japan and ESA, are currently studying pressurized laboratory modules for the manned base. Important motivations for providing these modules are their proposed utilization activities requiring Space Station crew interactions and opportunities for their own nationals to fly on board. Canada is studying the development of a mobile servicing center. It is possible that the Canadian participation would not be affected were the program to pause through a man-tended phase. However, the ESA contribution and the Japanese participation would probably be delayed to await the establishment of a permanently manned capability. Any prolonged period restricted to man-tended operation would likely require extensive re-evaluation and re-planning by all the partners.

Question 10: When does the decision concerning man-tended capability have to be made in order to adequately plan for the initial orbital capability?

Answer 10: If the United States alone were involved, this decision would have to be made no later than FY 1989 to avoid costly contract redirections and cancellations. Because of the international nature of the Space Station Program, however, it would be necessary to make this decision before our international agreements for the next phase of the program are initiated. Also, since payload development is impacted, an earlier than FY 1989 decision is required.

Question 11: According to your statement, the principal outstanding issue in the space station program is the restructuring of the work packages. Furthermore, I understand that the two options under consideration are: 1) four separate and equal work packages, modeled after the Phase B work package structure, and 2) one prime contractor that would oversee the entire Space Station Program and subordinate the activities of three of the field centers. What are the advantages and disadvantages of each option, and what cost savings, if any, are likely to be realized with either option?

Answer 11: We are currently examining several options for adjusting work package content. At this time, the prime contractor option as listed above is not under consideration. The four work package structure is retained in all the options which we are considering, but in no case are the work packages equal. The major features offered by all the options which we are currently studying are increased efficiency and clearer accountability. At this time the cost savings likely to be realized by any of the options are still subjective.

Question 12: How many personnel are committed to the Level B systems engineering and integration activity at Johnson Space Center, and could you compare this number with the number of individuals that performed this same function in the Apollo and Shuttle development programs? What plans are there to increase the number of individuals committed to Level B functions?

Answer 12: There are currently 100 civil servants at Level B dedicated to SE&I work. The Shuttle program had approximately 1150 civil service and contractor personnel performing SE&I functions during the peak of the development program. This 1150 estimate includes 75 to 100 Johnson Space Center SE&I personnel and 950 to 1050 contractor SE&I support personnel. This estimate does not include approximately 300 additional contractor personnel for other integration functions such as management (100), operations (75), payload (100-150), and customer (100-150). In the Apollo program, the number of civil servant and contractor personnel peaked around 2500 to 3000.

We are looking at a number of ways to perform the SE&I task for the Phase C/D activities. There are several options available to us including the use of some contractor support, but to date we have not made a decision on how best to meet the requirement.

Question 13: How effective would a phase C/D work package structure be that is modeled after the present Phase B structure, but with an enhanced and strengthened SE&I function, possibly in the form of an independent contractor?

Answer 13: We are currently examining the Phase C/D work package structure. However, an enhanced and strengthened system engineering and integration function is highly desirable, and we are examining various ways of providing it.

Question 14: I understand that one of the reasons why this formal ratification has been delayed is due to a conflict on whether or not ESA's pressurized module should be permanently attached to the Space Station framework, or detachable. What are NASA's concerns about the concept of a detachable module, and to what extent would the present baseline configuration accommodate a detachable module?

Answer 14: NASA has a number of concerns regarding the ESA proposed man-tended free flyer (MTFF). We are primarily concerned that periodic departures and arrivals of the MTFF at the manned base will be disruptive of ongoing experi-ments and will require a disproportionate share of crew time for check out and pre-docking and post-docking checks. Additionally, there may well be cost impacts to both NASA and ESA since MTFF will probably need a docking interface additional to those planned for the initial Station. Furthermore, critically needed laboratory facilities would be placed out of beneficial reach whenever the MTFF was detached from the rest of the manned part of the Station. In addition, NASA has not identified in the international data base any significant user community interest in this capability in the early years of Space Station. The user community has identified needs for continuous or near-continuous crew interaction with on-going experiments which would not be possible in the free-flyer mode.

Question 15: When do you expect ESA to establish its own autonomous space station facility, Columbus?

Answer 15: ESA has stated that it is Europe's goal to establish its own autonomous space station capability within the first decade of the next century. ESA has plans to develop the requisite spaceflight technology including a data relay satellite system capability, a station resupply and logistics system, the Ariane 5 launch vehicle, and possibly the Hermes manned spaceplane. It is important to recognize, however, that the development of such capabilities by a partner of the United States in no way precludes continued cooperation in the U.S. program. We expect that ESA and the United States will continue to cooperate in many manned space activities well beyond the next decade.

Question 16: Would you compare the servicing functions that both NASA and Canada have agreed to perform, along with the hardware and technologies that will support these servicing functions?

Answer 16: The proposed hardware element to be provided by Canada is a mobile servicing center (MSC) which will perform the following functions:

- attached payload servicing (external)
- Space Station assembly
- Space Station maintenance (external)
- transportation on the Space Station structure
- deployment and retrieval functions
- EVA support

The MSC will comprise a base structure with accommodations for payloads, orbital replacement units, utilities, and thermal control. Included with this structure will be the Space Station Remote Manipulator System as well as special purpose dexterous manipulators, end effectors and servicing tools. The MSC shall provide for external and internal control stations from which the crew shall control its operation. To aid the crew in servicing tasks, the MSC shall also provide astronaut positioning mechanisms. Technology developments related to the handling and positioning of large masses will be important to the MSC. Translation capability for the MSC will be provided by the United States.

As an adjunct to the MSC, Canada has proposed to provide a MSC maintenance depot with accommodations for power and data systems, maintenance fixtures, general purpose servicing fixtures and storage accommodations for the orbital replacement units for the MSC.

The United States will develop the Station servicing and refueling bay. This facility will utilize advanced automation and robotics technologies and will provide an enclosed but unpressurized volume for servicing and refueling free-flyer spacecraft such as the Hubble Space Telescope, the Gamma Ray Observatory, the Orbital Maneuvering Vehicle (OMV), and the Advanced X-Ray Astronomical Facility. This facility will provide a controlled environment (thermal and contamination) for exposed sensitive hardware. The facility is also used to service attached payloads which cannot be serviced in-situ. The facility includes a protective enclosure; a stationary crane; accommodations for mounting and rotating the item to be serviced storage for spare orbital replacement units; internal and external control stations; functional electrical interfaces to support servicing and checkout operations; and finally, a robotic servicer which can be used within the service bay, on the MSC, or with the OMV depending upon the location of the payload requiring servicing.

Question 17: What are the functional allocations that have been determined for the Space Station among the international participants, and are there any unresolved concerns about the functional allocations?

Answer 17: Formal agreements have been reached with Canada and Japan on the primary functions which will be allocated to the hardware they are carrying into preliminary design. The functions of the Canadian hardware are listed in the answer to Question 16. The Japanese have agreed that their module will accommodate general scientific and technology development research including microgravity research as well as control panels for the Space Station mobile remote manipulator system and attached payloads. Discussions on the functional role of European elements are continuing. Areas which must be addressed in the future with all partners includes the identification of generic equipment. The allocation of Station resources to the various elements must also be addressed.

Question 18: According to your testimony, you will soon establish a Space Station Safety Panel. Will this be a permanent panel, and generally, what will be the composition of its membership?

Answer 18: The Space Station Safety Panel will help us insure that our planning fully and properly accounts for safety issues. Its membership will include individuals from both within NASA and outside of the agency. The panel will serve during the remainder of Phase B as well as during Phase C/D. Towards the end of Phase C/D, we will reconsider the panel's composition and mandate.

Question 19: According to your statement, NASA has decided to retain safe haven facilities in the program as a safety feature. Would you describe the philosophy of a safe haven facility and its minimum requirements and capabilities?

Answer 19: Safe haven is a Space Station concept designed to provide for crew safety in the event of a major accident or subsystem failure which would render a portion of the pressurized volume uninhabitable up to and including the functionality of an entire module. This includes protection against fire, depressurization, contamination, and the loss of life-supporting subsystem elements. This concept has been evaluated in the definition of the Space Station and will continue to be examined during the preliminary design phase.

Specifically, safe haven means that there will be sufficient volume, atmosphere, food, water, power, temperature control, and emergency medical supplies to sustain the entire Space Station crew in an isolable volume for a period of time equal to the worst case estimate of the time necessary for a Shuttle to effect a rescue. This value for the definition studies is 28 days. The safe haven capability would exist in both the U.S. habitat and laboratory modules. Both of these modules would be accessible from either end, both would be fully isolable from the other modules, and would be capable of supporting a Shuttle rescue effort.

Clearly, the safe haven approach is sensitive to the operational characteristics of the Shuttle fleet. In view of the Challenger accident, the worst case time-to-rescue must be recalculated and might exceed the previous estimate of 28 days.

As more data becomes available, NASA will incorporate any new estimate into both the continuing evaluation of the present safe haven approach as well as the consideration of reasonable alternatives including the development of a "lifeboat" that would provide rapid, independent return of the crew to Earth.

Question 20: What are the projected annual operating costs for the Space Station, both permanently-manned and man-tended? What has NASA identified as the principal two or three operations cost drivers, and what is being done to minimize their impact on operations costs?

Answer 20: Operations costs are a function of system design. The principle cost drivers for Space Station operations are the use of the STS for logistics resupply and the maintenance, repair, or replacement of Space Station hardware over its lifetime.

Very preliminary estimates of annual operations costs for the permanently-manned Space Station run between $1.0 and $1.5 billion. Estimates have also been done on the impact to operations and life-cycle costs of a man-tended approach (MTA) versus the permanently manned capability (PMC). The current estimates of operations costs in a man-tended configuration indicate that such recurring costs would be within 10 percent of that for the PMC.

Since the cost of STS services per flight is fixed, NASA's efforts in reducing forecasted annual logistics costs is focused on reducing the number of logistics flights required. These efforts include the examination of alternative logistics concepts to determine the optimum combination of use of pressurized logistics modules and unpressurized pallets for transporting the wide variety of cargo required. By moving to close the environmental control and life support system, NASA will reduce the amount of fluids and gases to be transported. By employing a combination of solar dynamic and photovoltaic power, orbital drag, and therefore, propellant requirements are reduced. In setting standards for hardware lifetimes, NASA will reduce requirements for the transportation of spares and spare parts.

In the area of maintenance, repair or replacement of hardware, NASA is setting engineering performance standards which reflect the need to constrain operations costs. These standards for hardware lifetime, as well as the use of some hardware already flight-qualified, will serve to reduce annual operations cost in these areas.

Question 21: How will operations costs be shared with the international partners--has NASA established any fundamental philosophies for allocating operations costs?

Answer 21: NASA's current philosophy on the allocation of Space Station operations costs among the international partners is outlined by these principles:

Minimize operational costs;

Space Station systems operations costs should be allocated among the partners according to some "fair share" formula.

Operations costs to be shared should not include user payloads, other user-specific equipment, or payload operation control centers.

All partners desire to minimize the transfer of funds by identifying work each can perform in the operations phase in fulfillment of its respective share of operations cost responsibilities.

Question 22: In November, NASA released its Draft Guidelines for U.S. Commercial Enterprises for Space Station Development and Operations; industry responses were due in January. What was the nature and number of these responses, and how have these responses shaped NASA's approach toward space station commercial enterprises?

Answer 22: The industry comment period on the NASA Draft Guidelines for United States Commercial Enterprises for Space Station Development and Operations closed February 3, 1986. Thirty-two responses were received; 30 were positive and 2 were negative. The overall support to establish a new business-like relationship between NASA and industry, rather than the traditional government-contractor relationship, was tempered by the reality of standard business risk versus return considerations. While the comments clearly indicated that there is private sector interest in the Space Station, industry views space as having uncertain returns. In order for companies to become involved in the program, an economic environment needs to exist in space which reduces the unique risks of space and establishes more tangible returns. With the creation of the proper business environment for investment in space, the consensus of the comments indicate that there is commercial interest in the development and operation of the Space Station.

The guidelines will provide the policy framework necessary to support commercial participation in Space Station development and operations. In addition to the policy, the program is exploring ways to encourage commercial enterprises to propose business alternatives for specific Space Station systems and services.

Question 23: NASA has signed an agreement with Space Industries, Inc., whereby Space Industries will develop an Industrial Space Facility. What other considerations are being given to obtaining resources from external sources for additional pressurized volume and additional power, if needed?

Answer 23: The Space Station Program is supporting national and NASA commercial space policies. A number of Space Station systems and services may be potential candidates for private sector development. This list of candidates does include pressurized volume and non-critical power. These possibilities for commercial development will be considered in the Phase C/D procurement process.

Question 24: NASA has developed an extensive list of potential mission and user requirements for the initial space station. What accommodations, however, are included in the baseline configuration for future unknown users?

Answer 24: The Space Station user requirements database includes over 300 representative activities varying from individual instruments with discrete operational periods to experiments and processes to be conducted in pressurized laboratory modules. These user requirements represent a ten year range of user activities that the Space Station must anticipate for providing a balanced set of resource requirements. During the past year these user requirements were integrated into a functional requirements envelope to provide a performance goal to guide the definition studies. We are updating the functional requirements envelope and integrating these representative activities into a performance envelope to provide a resource profile baseline for detailed design and development of the manned base and the platforms. Incorporation of these performance requirements in the Space Station Program will provide a capability for accommodating a variety of known and unknown users and maximizing the value of the Station to commercial, science, and technology users.

Question 25: Has NASA developed a manifesting policy for the Space Station? If not, when will it be developed, and on what principles will it be established?

Answer 25: NASA is in the process of establishing manifesting principles for Space Station launch, assembly, logistics, and payload missions. Specifically in regard to manifesting Space Station cargo on the STS, since the STS launch manifests are routinely established only six years in advance and since the Space Station flights do not commence until FY 1993, no STS flights in support of the Station have been manifested to date.

Development of a policy for manifesting cargo onto the Space Station itself is still in the planning stages. A number of the principles upon which such a policy will be based will result from the international agreements which remain to be negotiated. When our total manifesting requirements are fully defined, the Office of Space Station will develop a manifesting policy in cooperation with the Office of Space Flight consistent with the agency's space transportation manifesting policy.

Question 26: Several companies within the commercial space industry have agreements with NASA to develop space hardware or provide on-orbit services to meet NASA requirements. (Examples include Orbital Sciences Corporation's Transfer Orbit Stage and Space Industries Inc., Industrial Space Facility.) Please describe any steps the Office of Space Station has taken to encourage commercial investment and involvement in the development of Space Station infrastructure.

Answer 26: The Office of Space Station's primary means to encourage commercial investment and involvement in the development of Space Station infrastructure will be the Commercial Guidelines of U.S. Commercial Enterprises for Space Station Development and Operations. As noted in the response to Question 22, these guidelines will provide a policy framework to encourage participation in Space Station development and operations by U.S. commercial enterprises which seek to develop with private funds Space Station systems and services.

In addition to the guidelines, the Office of Space Station will consider entering into cooperative arrangements to share Space Station Program information with U.S. firms. Our Memorandum of Understanding with Space Industries, Incorporated, is an example of Space Station Program support of commercial space endeavors. In addition, we are exploring the feasibility of pursuing a joint NASA and industry venture in automation and robotics.

Question 27: As I understand, NASA is planning to build two OMVs, one for the Shuttle and one for the Space Station. From which budgets will both of these OMVs be funded? Will the Space Station OMV be available when the initial Space Station is operating in 1994? If not, why?

Answer 27: The Office of Space Flight will fund the first OMV. The Office of Space Station will fund the second OMV. The current plan for the initial Station does not include a Station-funded OMV. The Shuttle OMV is expected to be ready and available for shared use on the initial Station. That single OMV is expected to adequately handle all requirements of the initial Station.

Question 28: How will the capabilities of these two OMVs differ, and if the space station OMV is not available when the initial space station is operating, how will this affect space station operations and capabilities?

Answer 28: The two OMV's are planned to be inter-operable. This interoperability is reflected in the requirements and designs currently being evaluated by the OMV source evaluation board. The only feature not common is the ability to communicate directly from the OMV to the Space Station, rather than using the Tracking and Data Relay Satellite System (TDRSS) link. This feature would not be needed until some time in the future, when the Space Station will assume the role of detailed and intricate in situ servicing of space assets. The Office of Space Station and the Office of Space Flight are both aware of this future need, and provision for this capability will be negotiated with the contractor selected for OMV development.

The Space Station Program does not plan to procure a separate OMV for the initial Space Station. We plan to negotiate a method for sharing the Shuttle OMV in the near future. The sharing of the OMV will mean that the initial Space Station will only have an OMV based at the Space Station intermittently.

Question 29: In a report that NASA prepared for this committee on NASA's plans to implement the recommendations of the Advanced Technology Advisory Committee (ATAC), NASA is incorporating the automation and robotics (A&R) technologies that are required for space station assembly, servicing, and routine operations. What is the projected total cost of developing and implementing these A&R technologies, and would these costs be contained within the projected $8 billion space station cost? Would these A&R technologies be available all at once, or would they be phased-in? How will these technologies compare to the technologies that are being developed by our foreign competitors?

Answer 29: The precise nature and the cost of the A&R required for routine operations of the Space Station will be determined during the preliminary design portion of the Phase B effort and the evaluation of the industry Phase C/D proposals.

It is expected that the A&R technologies will be phased in over a period of time. In fact, it is a key philosophy of the Station's design that it be "scarred" to allow for future incorporation of advances in automation as the technology evolves during the life of the Station.

In general, our work in space A&R is comparable or more advanced than that of our foreign competitors. However, the balance of the comparison will depend on the final design of the Station. For example, the United States leads in practice and concepts for remote space manipulation and servicing, but not in automated berthing and docking. In cognitive tasks the U.S. technology is generally at the leading edge.

Question 30: According to this same report, another level of A&R technologies that NASA has identified is that which will enhance the productivity of the space station. Are these technologies also included in NASA'S basic space station program? How much would it cost to develop and implement these technologies, and when could they be available?

Answer 30: Some A&R technologies that would enhance productivity on the Station will be included in the basic Space Station Program. Some will be available at initial orbital capability, but most will be for later implementation. However, the precise nature and cost will be determined during the preliminary design portion of the Phase B effort and the evaluation of the industry Phase C/D proposals.

Question 31: To what extent would the implementation of these A&R technologies be affected by a decision to operate in a man-tended mode for some period of time before proceeding to a permanently manned mode? Does either capability introduce additional costs into the development and implementation of these A&R technologies?

Answer 31: The study of a man-tended mode assumed no unusual events and no acceleration of A&R development. Thus, it is expected that A&R costs would be unchanged under this approach.

Question 32: When will the positions of Associate Administrator of Space Station and Director of Level B, Office of Space Station, be permanently assigned?

Answer 32: The Associate Administrator for Space Station and Program Manager at Level B will be named following Dr. James C. Fletcher's appointment as the NASA Administrator.

QUESTIONS OF SENATOR RIEGLE AND THE ANSWERS

Question 1: How in light of this series of reductions, can the initial operating capability (IOC) date for the Space Station still be 1994? Has the cost of the Space Station at IOC gone down? For example, is it true that by 1994 the current estimates of NASA spending for the core station will only be $6.6 billion -- not $8 billion? What additional capabilities will the $1.4 billion buy that won't be included in the IOC station?

Answer 1: Cost constraints, both current budget reductions and projected annual runout costs, have required an adjustment in Space Station content and phasing. The result is a program based on achieving a permanently manned Space Station capability by 1994 to be followed soon thereafter (1995 or 1996) by the full baseline configuration capability. The estimated cost of the Space Station is still $8.0 billion in FY 1984 dollars for the baseline configuration.

The $6.6 billion should be put in context. When examining the runout of the budget estimates through 1991, the total amount of money proposed in 1987 dollars for the development of the Space Station is $6.6 billion. This would be somewhat less than $6.0 billion in 1984 dollars which is the correct reference relative to the $8.0 billion.

Question 2: Would you please give the Subcommittee a list of the components of the IOC space station? Does IOC still assume that the U.S. will develop a co-orbiting platform and a polar platform? What effect, if any, does the concept of "functional allocation" have on the treatment of platforms -- couldn't they also be given different tasks in an effort to save money and diversify the Station's capabilities?

Answer 2: A list of the components of the permanently manned configuration includes the following: all necessary structural and support components; power supplied by photovoltaic solar arrays; the U. S. laboratory and habitability modules; the U. S. polar platform; nodes, tunnels, and airlock; the Canadian-supplied mobile servicing center; payload and payload support equipment; and the logistics module. The components for the baseline configuration include the solar dynamic power system, the servicing facility, the remaining platforms, and the remaining international elements including laboratory modules provided by ESA and Japan.

The program content includes development of a U. S. co-orbiting platform and a polar platform. The Space Station Program intends to apply the principle of functional allocation to the platforms. NASA believes that this principle does not preclude assignment to a given platform of specific tasks (e.g. earth observation or x-ray astrophysics). In this manner, the Program may potentially save money and diversify the Station's capabilities thus satisfying the broadest range of user needs.

Question 3: At IOC, will the Space Station be a permanently manned Space Station or will it be a man-tended space station? Would you please give the Subcommittee your preliminary findings concerning the cost and capabilities of a permanently manned Space Station versus a man-tended space station? What effect would implementation of a man-tended approach have on the level of participation by our foreign partners?

Answer 3: At IOC, the Space Station will be a permanently manned facility. The man-tended capability, now baselined in the Space Station planned assembly sequence, provides an opportunity to pause in our development of a permanently manned Station. Its major deficiency lies in a lower utilization of the laboratory facilities. Most experiments intended for the manned core of the Space Station are crew-time intensive and cannot be easily accommodated during visits of the Shuttle which are limited in duration. These experiments include life sciences experiments involving humans and animals, which are vital to advancing our knowledge about long-duration space flight, and most materials research experiments that would lay the groundwork for future commercial utilization of space. NASA believes that there are no compelling advantages to operating in a man-tended mode, other than the possibility of deferring some costs. NASA also believes that a man-tended station would be similar to a Spacelab-type capability, and thus would not represent a substantial improvement suitable for the 1990's.

Calculated in FY 1984 dollars, based on the President's FY 1987 budget request, and assuming man-tended operation for three years, our estimates are that approximately $280 million could be deferred through FY 1991 assuming that the mobile service center is supplied by the U.S. The total development cost of the permanently manned Space Station, if this man-tended phase were added, would be about $1.0 billion more through FY 1997 with a three year delay, than the estimated $8 billion needed to complete the permanently manned facility without delay.

We have not pursued the development of international agreements for participation in a man-tended space station. It is possible that the Canadian participation and the ESA platform participation would not be affected were the Program to pause in a man-tended phase. However, the ESA laboratory and the Japanese participation would probably be delayed to await the establishment of a permanently manned capability. It is important to remember that the Space Station international partners have based their policy and technical decisions on participation in a permanently manned Space Station.

Question 4: What impact does the concept of functional allocation have on the future use of the Space Station for Department of Defense research and development? Could any member of the Space Station core team refuse access to DOD experiments? How could DOD experiments be conducted in an environment where there is open access by all participants? Has DOD indicated any desire to conduct experiments on the Space Station?

Answer 4: The concept of functional allocation should have no adverse impact on the potential future use of the Space Station by the Department of Defense or any other user. While DOD has not currently identified any requirements to use the Space Station, adequate safeguards would be possible for DOD research projects, safeguards not unlike those which will be available for the proprietary applications of both domestic and international commercial users.

Question 5: Does the concept of functional allocation really result in a series of unique modules? Isn't it clear that the Japanese module as well as the ESA module will conduct materials processing experiments?

Answer 5: The application of the functional allocation concept will provide facilities for the user community which are best designed and equipped to perform a specific function. Functional allocation assignments will facilitate the preliminary design of such pressurized laboratory attributes as secondary structures and specialized provisions for utilities. The objective of functional allocation is to provide an integrated design for each Station facility which takes into account the needs of all partners in that functional area. Reconfiguration of the modules will be possible to accommodate both specialized experiment hardware and changes in user requirements. While the U.S. laboratory module will provide accommodations for materials research involving the lowest levels of acceleration, microgravity research in the other laboratory modules is not precluded.

Question 6: What impact does the functional allocation approach have on the level of activity of NASA centers and U.S. manufacturers? Does the United States plan to add additional modules to the Space Station configuration? What type of modules?

Answer 6: The overall level of activity for NASA centers and the U.S. manufacturers would not be decreased by using the functional allocation approach. The greater levels of activity in the areas of microgravity research, automation and robotics and other functions allocated to the United States should compensate for the allocation of other functions to ESA, Japan and Canada. Future growth of the Space Station including additional modules, is currently under consideration, but no formal plan has been determined at this time.

Question 7: What is the ultimate goal of the functional allocation approach to the Space Station? Is it really driven by concerns about cost or is it based on the need to make the Space Station a truly international laboratory of which each participating nation is an integral and permanent component?

Answer 7: The objective of the functional allocation approach to the Space Station Program is to maximize the capabilities of the initial Station in order to accommodate the greatest possible range of user activities within the available resources. The budget resources of all the Space Station partners in the program are limited, and the allocation of functions among the elements provided by the partners, coupled with open access by all partners to all Station capabilities, is the most economical way to accomplish the overall objective of satisfying the broadest range of user requirements.

Question 8: What is the current status with ESA concerning the Phase B definition program? Are the U.S. and ESA differences reconcilable? Will the resolution of the Phase B negotiations facilitate the final C/D negotiations?

Answer 8: NASA has just received and is preparing a response to a revised proposal from ESA which clarifies the ESA pressurized laboratory and co-orbiting platform element contents and functions. NASA has indicated to ESA its desire that ESA provide a permanently attached laboratory module, a polar platform, and a co-orbiting platform as elements of participation in the program. NASA believes that open issues are reconcilable and resolution will facilitate upcoming negotiations for the development and operational phases.

Question 9: What, if any, are the possible "show stoppers" for the Phase C/D negotiations? Is this a reasonable scenario in light of the Phase B definition activities experience?

Answer 9: Currently, there are no "show stoppers" or insurmountable issues which would prevent successful conclusion of international Space Station agreements for the coming phases of the program. There are, however, a number of substantive issues to be resolved during the upcoming negotiations such as management relationships, legal regimes, sharing of operational costs, and allocation of Station resources. The current plan is to initiate formal, bilateral negotiations in June of 1986 with the objective of reaching agreement on texts by late 1986 or early 1987 and formally signing agreements by April, 1987. This schedule applies to agency-to-agency agreements between NASA and the international counterpart agencies as well as to umbrella government-to-government agreements.

Question 10: Will the Space Station be a truly international Space Station? Is it being designed as a partnership -- all members are equals -- or is it being designed as a U.S. Space Station?

Answer 10: While the Space Station is being planned as an international cooperative partnership, it is recognized that the United States has provided the initiative and is recognized as the predominant investor in the program. The United States will be the predominant user of Station capabilities and will have the lead responsibility in areas such as overall system integration, transportation, top level requirements control, and safety and system operation. It is expected that the international partners will have management roles commensurate with their development and operational responsibilities and investments. NASA believes it is in the interest of the United States to have a genuine partnership in the Space Station Program.

Question 11: To what extent will new technologies be developed by our foreign partners in the Space Station Program? To what extent will new technologies be developed by the United States? In particular, what new automation and robotics technologies will be developed by the United States? What similar technologies will be developed by Canada? Will these systems complement each other or be in competition with each other?

Answer 11: We have no information at present about the extent or application of foreign advanced technologies as they are incorporated into the foreign contributions to the Space Station. The automation and robotics technologies that will be developed by the United States are focused in the following areas: sensing and perception; operator and machine interface; execution control; system architecture and task planning. Both the United States and the Canadian systems will be defined in detail during the balance of the preliminary design phase. The preliminary design agreement between NASA and the Canadian Ministry of State for Science and Technology is based on a division of principle functional responsibility for the respective hardware. Under this agreement the hardware would perform complementary functions.

The major U.S. focus of new technology development is to develop selected technologies to the extent required to gain the benefits of longer life and lower operational costs for the Space Station.

Question 12: What is the current status of the "end effector" debate? Has a solution been worked out that meets the Congressional requirements as well as satisfies the requirements of the Canadian government? Is the "end effector" a major automation and robotics advancement?

Answer 12: Both NASA and the Canadian Ministry of State for Science and Technology (MOSST) plan to develop dexterous robotic devices for required Space Station servicing functions. Both of these devices will be designed so that they can be used in several ways, which includes functioning as end effectors on the Space Station remote manipulator system. An agreement between NASA and MOSST has been reached on different primary functions for the two robotic devices. It is believed that this approach will satisfy both U. S. Congressional and Canadian interests to stimulate their respective robotics industries. The NASA telerobotic system will be used primarily to service visiting spacecraft such as the Hubble Space Telescope and to service attached payloads moved into the manned base servicing enclosure. That same system or a duplicate will be used later as the smart front end on an orbital maneuvering vehicle to perform in-situ servicing of free-flyers. The planned Canadian dexterous manipulator will be used for Space Station repair and large space structure assembly activities. It may also be useful for some external payload in-situ service functions. It is anticipated that both the U.S. and Canadian systems will be used as back ups for each other as needed. The development of such end effectors can be considered as major new applications of currently emerging automation and robotic technologies.

Question 13: NASA is currently responsible for the systems engineering and integration activities of Phase B -- the system definition program. Does NASA still plan to oversee the systems engineering and integration activities in Phase C/D (the hardware development phase) or will NASA contract for these services? What assumption is made in the FY 1987 budget request concerning these activities?

Answer 13: Our plan is to retain responsibility for the overall Space Station system engineering and integration activity within NASA throughout the design, development, and operation of the Space Station. We will, however, require some contractor support to accomplish this. The nature of that support is currently being defined. However, we expect that it will be a significant effort in FY 1987.

Question 14: What is the current complement of in-house NASA manpower that is being supplied for the Space Station program? Would you please break that down for the record by space and research centers?

Answer 14: The total in-house NASA staff that is being supplied for the Space Station Program in FY 1987 is 2163. The details are as follows:

CENTER	NASA STAFF LEVELS
Ames Research Center	11
Goddard Space Flight Center	200
NASA Headquarters	68
Johnson Space Center	815
Jet Propulsion Laboratory	35
Kennedy Space Center	244
Langley Research Center	55
Lewis Research Center	280
Marshall Spáce Flight Center	455
TOTAL	2163

Question 15: What is the current status of the work package restructuring activity? When will you be able to inform the Subcommittee of the final NASA recommendations? If you recall, there was a great deal of Congressional interest in the work package formulation -- can we expect to hear from you soon on this matter?

Answer 15: Currently, the Space Station work packages are being carefully reviewed. We have issued instructions to the NASA centers to reduce overlap among the current work packages without instituting major changes in center responsibilities. All the work package plans under study call for the retention of a four work package structure. However, the scope of any reconfigured work packages will not be equal. The major advantages offered by all the options are increased efficiency and clearer accountability.

Work package roles and responsibilities will have a major influence on the character of many NASA field centers for years to come; for that reason, we believe it is appropriate that the decision on work packages await the action of the new NASA, Administrator, Dr. James Fletcher.

Question 16: Finally, based on the investigation of the shuttle accident, it is clear that the lead center concept has certain liabilities. What is being done within your office to correct the deficiencies in this management concept? Can

Headquarters effectively manage a program of this scope and complexity? Or should the position of Associate Administrator for Space Station be housed at one of the centers?

Answer 16: We are presently reviewing our current management structure regarding its applicability to the development phase of the program. Because the Space Station program is multi-centered, any change in the current management will be reviewed and approved by the Administrator before it is implemented. If changes in NASA policy regarding the lead center concept do result from the current Challenger investigation, such changes will be applicable to the Space Station Program to the extent that the lead center concept is used by that program.

Question 17: If the Congress ultimately decides to pursue this option -- freeze Space Station funding and stretch out the program -- what effect would this have on the Space Station Program? Why is it critical that the Congress initiate phase C/D (the hardware development phase of the program) in FY 1987?

Answer 17: If Space Station funding were held to last year's funding level, the effect would be extremely negative. The entire Space Station planning effort in the President's budget has been built upon initiating Phase C/D in 1987. Not to do so might be interpreted by the user communities, the program planners and engineers in industry, and to the Space Station international partners that the U.S. commit-ment to the Space Station Program is waivering

Question 18: What is the minimum, and I emphasize minimum, level of funding required by the Space Station Program in FY 1987 to initiate Phase C/D of the program? What effect would such a reduction have on the 1994 IOC date and the overall cost of the program? What activities would be reduced or phased out in FY 1987 if the funding level were reduced?

Answer 18: The minimum level of funding required by the Space Station program in FY 1987 to initiate Phase C/D is $410 million: $260 million for definition and $150 million for the commencement of development activities. NASA's FY 1987 Space Station budget request to the Office of Management and Budget was decreased from $600 million to $410 million. The majority of these reductions occurred in the development phase which was reduced from $270 million to $150 million. This lower development budget was determined to be the minimum funding level required to successfully initiate this next phase of the program and to still meet the President's direction to have a permanently manned Space Station within a decade. Any further reduction in the program funding would likely cause a delay in the 1994 schedule, increase the estimated cost beyond $8.0 billion, and require extensive program replanning.

Question 19: What is the current runout of spending for the Space Station Program? How does that compare with the FY 1986 budget assumptions and the FY 1985 budget assumptions?

Answer 19: The current funding runout for the FY 1987 Space Station budget is as follows (in real year dollars in millions):

FY 1987	FY 1988	FY 1989	FY 1990	FY 1991	BTC	TOTAL
410.0	1000.0	1800.0	1950.0	2170.0	4470.0	11800.0

In the FY 1986 Congressional budget request, the funding was approximately 20 percent higher through FY 1991 than the current FY 1987 Congressional budget submit as follows (in real year dollars in millions):

FY 1987	FY 1988	FY 1989	FY 1990	FY 1991	BTC	TOTAL
580.0	1050.0	2070.0	2270.0	3310.9	1741.6	11022.5

In the FY 1985 Congressional budget request, the funding was approximately 17% higher through FY 1991 than the current FY 1987 Congressional budget submit as follows (in real year dollars in millions):

FY 1987	FY 1988	FY 1989	FY 1990	FY 1991	BTC	TOTAL
1250.0	1650.0	2070.0	2270.0	1504.0	1790.0	10534.0

The totals for each of these budgets equate to approximately $8.0 billion in FY 1984 dollars.

Question 20: Would you please explain to the members of this Subcommittee why it is so difficult to get OMB approval for the Space Station Program -- supposedly a high priority of the Reagan Administration? What impact, if any, will the required funding for a new orbiter have on Space Station funding -- will it also be reduced to absorb part of the new orbiter cost?

Answer 20: While the OMB reviews all agency requests for funds and understandably seeks to balance all such requests, they are fully supportive of President Reagan's Space Station initiative. The Administration has, in fact, included Space Station development in the President's FY 1987 budget proposal. In regard to the question of restoring the pace and progress of the Nation's space launch capability and civil space program, The Administration has not yet concluded its deliberations.

Senator GORTON. The next witness will be Mr. Richard Smith, Principal Deputy Assistant Secretary on Oceans and International Environmental and Scientific Affairs, Department of State.

Mr. Smith, you are welcome. Your written statement will be included in the record as if read in full. We will be happy to have you summarize, if possible.

STATEMENT OF RICHARD SMITH, PRINCIPAL DEPUTY ASSISTANT SECRETARY ON OCEANS AND INTERNATIONAL ENVIRONMENTAL AND SCIENTIFIC AFFAIRS, DEPARTMENT OF STATE, ACCOMPANIED BY RALPH BRAIBANTI, OFFICE OF ADVANCED TECHNOLOGY

Mr. SMITH. Thank you very much, Mr. Chairman. I would appreciate that opportunity, and very much appreciate your invitation to be here. Perhaps I could introduce Ralph Braibanti, who is with the Office of Advanced Technology in the Bureau of Oceans and International Environmental and Scientific Affairs.

Mr. Chairman, the Department of State does appreciate the opportunity to testify before this committee on the foreign policy aspects of the space station, in addition to discussing how the space station relates to U.S. foreign policy objectives. I would like to describe in general terms the progress that has been made in bringing our allies into the Space Station Program, and to outline some of the issues that may arise when we begin to negotiate agreements regarding international participation in the development, operation, and utilization phases of the program from the State Department's perspective.

The President's manned space station initiative has the potential to yield significant foreign policy benefits. The U.S. leadership in space has served our country well both as a symbol of technological prowess and in practical terms. We cannot stand still if we are to remain in the forefront of space exploration. The Soviet Union, and this has been noted earlier, is moving ahead with ambitious space programs, and Europe and Japan are developing their independent capabilities.

The space station is a centerpiece of the U.S. Space Program for the 1990's. The successor to Gemini, Apollo, and the space shuttle, it is an essential next step if the United States is to preserve its leadership in space. From the outset, we have seen the Space Station Program as an opportunity to strengthen our ties with key allies. The foreign policy dimensions of allied involvement in the program extend beyond the immediate objective of establishing a permanently manned presence in space. The strength of the western alliance is due in large measure to the power and vigor of western technology. The space station could be a major factor in stimulating further technological advances. Moreover, the arrangements we work out for the space station could have a profound and lasting effect on cooperation among western industrialized nations, establishing a model for cooperation in large scale technology projects.

Our allies' response to the President's invitation to participate in the space station has been enthusiastic. In the spring and summer of 1985, the appropriate Canadian and Japanese science and technology agencies and the European Space Agency, ESA, signed memoranda of understanding with NASA governing their participation in the detailed definition and preliminary design phase or phase B of the space station program.

Canada, Japan, and Western Europe have already invested millions of dollars in the phase B preliminary design studies they are conducting in parallel with NASA studies. This is only the beginning. All of the international partners have indicated their intent to continue into the development, operation, and utilization phases, phases C/D and E of the program, subject, of course, to successful completion of their design studies, satisfactory negotiation of follow-on agreements, and the availability of funds. Soon, we hope within the next month or so, NASA and the Department of State expect to begin negotiating agreements for phases C/D and E of the space station program.

These negotiations will not be easy. The cooperative arrangements among the partners promise to be extraordinarily complex. Our partners will want to ensure that their interests are protected. National pride and large sums of money are involved. The Europeans have requested and we have agreed to negotiate both, one, a government-to-government agreement to be signed by the United States and the European Space Agency member governments and two, an agency-to-agency agreement to be signed by NASA and ESA.

The Japanese and the Canadians are currently considering whether they desire to have similar arrangements, or whether in their cases agency-to-agency agreements will suffice.

Among the State Department's broad objectives in the negotiations will be to ensure that international participation enhances the space station, to ensure that the project strengthens our relations with our allies, to help devise a framework for international participation that demonstrates the attractiveness of working with the United States in space and in other areas of advanced technology, to prevent adverse technology transfer, and, finally, to ensure that the legal regime governing international cooperation on the space station is consistent with U.S. long-term interests in outer space law.

In preparation for these negotiations, State and NASA have already held a number of preliminary talks with the allies, most recently in Paris last week. Our initial discussions lead us to believe that there will be many difficult issues, but we are confident that the negotiations will succeed. The State Department has been working very closely with NASA, and will soon be engaged in intensive consultations with other departments and agencies that have expertise or an interest in some of the issues. We also, of course, want to work closely with this and other committees and subcommittees of the Senate and the House so that the views of Congress will be fully taken into account in the intergovernmental arrangements that emerge from our negotiations.

We want the space station to be a true partnership that sets new standards for cooperation and large-scale technology, preserves U.S. space leadership, and strengthens the Western alliance. Thank you, Mr. Chairman.

Senator GORTON. Mr. Smith, will deferring the initiation of phase C/D development until 1988 have an adverse impact on international participation?

Mr. SMITH. Mr. Chairman, in our view, any significant delay in the Space Station Program would weaken the prospects for the kind of cooperation we are trying to seek. It would call into question our reliability and future high-technology cooperation with the allies more generally also.

Senator GORTON. According to your testimony, the United States and ESA will negotiate a government-to-government agreement while NASA and ESA will negotiate an agency-to-agency agreement. I gather that this is different from the way we will negotiate with Japan and Canada, and why do we need two different sets of agreements?

Mr. SMITH. This was done at the request of the European countries that belong to ESA. Their concern was that there be an overriding government-to-government commitment which dealt with the nontechnical aspects such as technology transfer, and property rights, and we are responding to their desires in that regard. We do not know yet whether the Japanese and the Canadians will also seek that kind of a general government-to-government agreement in addition to the agreement with NASA.

Senator GORTON. I understand that some of those, some of the Europeans would like to have that government-to-government agreement at least formalized in the form of a treaty, and both, I suppose, for its status and because the Senate would then be required to ratify it, and that ratification would perhaps be an additional commitment on the part of the Senate to pursuing the program. What are your ideas on that subject?

Mr. SMITH. Well, this is something that we will be discussing and have been discussing with our partners, and we will continue that as negotiations get underway. You are correct that some discussion has revolved around the idea of whether a treaty, as opposed to another type of agreement, would indicate of a clearer commitment on the part of the United States to this process. I think that is largely what is in their mind.

I chaired our first set of consultations on this subject, and clearly one of the things that the ESA countries are looking for is a signal of a clear long-term commitment on the part of the United States. The subject of what form this agreement would take is open, and I do not think anything has been ruled out. We just have not really come to decisions on that yet.

Senator GORTON. Are any serious attempts being made to renegotiate the United States-Soviet Space Cooperation Agreement, which lapsed some 4 years ago, and is it the Department of State's view that we should consider developing technologies compatible with the Soviet space station?

Mr. SMITH. Mr. Chairman, in principle we believe that cooperation with the Soviets in space can be worthwhile provided the cooperation is structured in such a way that it is mutually beneficial, and that the projects are scientifically valid and technologically sound, and that the risk of adverse technology transfer has been reduced to a minimum.

In the specific case of the space station, this was a U.S. initiative at the London Economic Summit for cooperation among our closest allies who were eager to participate in the project. We do not in our present plans envision Soviet cooperation in the space station project. We, of course, cannot predict the future. Any decision that would be made in the future would naturally involve all of the partners in the space station project.

Senator GORTON. Thank you.

Senator Riegle.

Senator RIEGLE. Thank you, Mr. Chairman. Mr. Chairman, just two things, and that is that you indicate in your statement that it was necessary to explore some unchartered territory in these arrangements, and in particular as regards the operations and the cost of the station and the legal regime. First, I am wondering if these issues concerning operation of the space station are included in the approach that we are anticipating and how we are doing it here? Second, should we think of it as a U.S. space station or as an international space station?

Mr. SMITH. Well, we are at—and this is true on a number of other questions—an early stage, and my own view is that we need to emphasize the cooperative nature of this. Although our commitment to the station financially is certainly larger than those of others, in their own terms and in relation to their own budgets, these are huge commitments that our partners are making. I certainly think it is appropriate to think of it in terms of a cooperative venture, with the United States playing a very large and critical role.

Senator RIEGLE. Would we own it together? I mean, how would the ownership issue be seen?

Mr. SMITH. I think these are the kinds of questions that we would have to deal with, in terms of the detail and the legal status. Once one says in general that we cooperate on it, we each have pieces of it which we particularly have developed and own. With regard to the entire station, the answer to the kind of question you raise, I think, is something that will have to be developed.

Senator RIEGLE. So we do not know the answer to that now?

Mr. SMITH. I would say that that is the kind of question that we need to address.

Senator RIEGLE. Have you worked out yet procedures as to what happens if we want to do one thing and our partners want to do something different, and the conflict resolution process?

Mr. SMITH. We have had considerable consultation on that, but again, we have not yet begun our negotiations on the government-to-government agreements, and so I cannot say that any decisions have been made in that regard.

Senator RIEGLE. I guess I worry some, too, about just the political implications. Governments change, and if we are tied into relationships with other countries where the political lay of the land changes and there are other issues and, you know, the degree to which we are able to screen that out of an ongoing common space mission. Do you have any anxiety about that at all?

Mr. SMITH. Well, I think it is an appropriate concern, and one which indeed is central to what we are trying to address in the government-to-government consultations. We want to make sure that we are dealing with long-term commitments that do not change from government to government, and that there is a structure and an understanding with regard to the legal regime and the kinds of questions that could arise that it will stand up and it will be a commitment from the beginning. We will try to anticipate and resolve in that sense these issues to the extent we can.

Senator RIEGLE. I think we really are moving into a brandnew area here. When one rereads the history of the cooperative efforts in World War II, I mean, where now skilled historians have gone back and reconstructed what went on, there were incredible tensions between the Allies and differences of opinion as to the objectives, and oftentimes we appear to have been working at cross-purposes, and yet in the end we won the war, thank God.

But I am just wondering, on something as critical as what we are doing here, while the idea of a joint international operation has great attractiveness and I am drawn to the idea of making this a venture that can include others in a meaningful way, I think there are some very important U.S. goals and objectives that have to be met because I think we are behind. We are clearly behind the Russians by a number of years, and I do not think we can afford to be slowed down. I think we are going to have to move with some very deliberate rate of speed, and I must say as I watch international endeavors it is awfully easy to get tied in knots on agreeing to a common agenda and sequencing events.

We have just gone through this exercise with trying to work out international cooperation in other fronts, and with a very mixed record of success, and I am just—I guess I would just want to file a concern that I have in my mind as to how far we want to go in that area. I would like to have international participation, but I think I lean in the direction of saying that the strategic importance of what we are doing here and the fact that I think we have a very important gap to close with the Soviets means that we have to have a very streamlined ability to make decisions and move, and I do not want to jeopardize that.

I would think that would be a very serious mistake, and so I guess what I would like to hear from you now and as we go down the road is, I would like to hear some very clear assurances that we are not out there lost in the murkiness of complicated signoff type decisions and mutual agreement activities and so forth when we are going to have to be able to move here, I think, efficiently and quickly and in line with our own interests.

Mr. SMITH. Well, I certainly do not want to in any way belittle the complexity and difficulty of the issues you have raised. At the same time, I am encouraged by what we have done so far. One of the reasons we have been moving in parallel on the government-to-government discussions, which now will become negotiations, rather than waiting for the technical agreement to be concluded, is because we have recognized we cannot wait. These are tough questions. We have been holding discussions on a very accelerated schedule starting last fall on an almost monthly basis, either here or in Europe. We are deeply engaged in the questions. They are difficult. They are not yet resolved. But I am encouraged that if we continue to work the way we are, we can come to grips with them, and that we will have appropriate control on the U.S. side, and that at the same time we can meet the very legitimate needs of our partners to be partners.

Senator **Riegle**. Well, I am not a lawyer, and sometimes that is an advantage in this business and sometimes it is a disadvantage, but when you say to me that we do not know now whether this is going to belong to us, to be a U.S. space station, or whether it is going to be an international space station, the way my mind works, it seems to me that that is one of the very first questions you have to answer, and then from that flow a lot of other things. I do not know that. Maybe that is an answer you back into down the line. But that just leaves me feeling uneasy when we are moving ahead and we do not have even that kind of a basic question answered.

Mr. **Smith**. Senator Riegle, I am not a lawyer either, but I agree with you that that is a tough question, and it is not one we are backing into, but is one we are facing up to and coming to grips with. We have to recognize that we are operating in a new area. There never has been a permanent presence of men in space, and it does raise all kinds of very complex and uncharted legal areas to look at.

We are deeply engaged, and have been for months now, and we are going to resolve these early in the game, and I am confident we can do it.

Senator **Riegle**. Well, I think you are going to have to keep us posted, because if it turns out that things are not fitting together, we may have to review this whole question again.

Mr. **Smith**. Indeed, and we intend to.

Senator **Gorton**. Senator Heflin.

Senator **Heflin**. I think Senator Riegle raises some interesting points, some that I had had in my mind, but I think he fleshed out additional questions there. You have got some real problems on sovereignty rights and patents and antitrust laws and all of these that could arrange some countries to not recognize our patent laws, and companies making investments and similarities of experiments that might take place just in the patent field, and differences that can be the international competition that arise relative to that.

The matter that comes up to me is the quagmire we are in relative to the Law of the Sea, and then you get into it where some minerals in the Law of the Sea, that beyond certain sovereignty rights, that they would be shared under a U.N. concept with certain countries, underdeveloped countries, and there are all sorts of problems like this, and perhaps maybe from a space station can be developed satellite space stations that act as new sources of energy and power, and all of this raises sovereignty rights.

I think it is an interesting field, that at this stage I think we would be neglectful if we did not look at it and attempt to identify all of the different concerns and attempt then to give some directions. If it is under some international control, we might have to seek permission to take off against the Martians or something else one of these days to end terrorism on Mars, and we might not have the consent and that sort of thing, and so you have got all sorts of problems that could arise as you get to thinking about this, so I think you have raised a very interesting question, and I just think it is a concern that at this very embryonic stage that some think tanks ought to start looking into the matter.

Senator **Riegle**. If the Senator would yield, just one other thought I have on that, and that is the Soviet Union. Now they have put a lot of emphasis in this area and they have a functioning space station. The evidence that is clearly out in the public record is to the effect, as I was saying earlier, that they have performed over 1,600 experiments in materials processing. So they have got a very serious effort under way, and it is going to be 8 years before we have this thing up there, if everything goes right. So we are lagging behind very substantialy, and they have the luxury, if you will, of being able to make unilateral decisions. If they want to do something with their space station, presumably they can do it within their structure because they do not have a consortium of partners.

Now, obviously, they have got to pay for it all, too, so they are not getting help on the investment side. But it seems to me that if you are in a situation where you have got strategic matters that are involved, and you are behind, and you have got to move with speed, obviously competently, but with speed, whether or not you want to be tied up in elaborate international consortium arrangements, I think is a question that has to be looked at with some care.

I mean, I prefer cooperative ventures if we can, but I think here we are very considerably behind. I do not think the public knows this. I think when the public finds out we are this far behind, they are not going to like it, and they are going to wonder why and where were the decisions made, and how did this come about. I mean there is no quick answer. The quick answer comes in 1994, if everything works right, and so I just do not want us to be hamstrung, and so if we cannot work out agreements that give us the kind of operating flexiblity to move at top speed, then I am not sure that we are meeting our own requirements.

Mr. **Smith**. Well, we certainly agree. Your point is very well taken in that regard, and we will need your help and counsel as we go along, and we will be seeking it.

Senator **Gorton**. There will be additional questions submitted to you in writing, the answers to which we would appreciate.

Thank you very much, Mr. Smith.

[The statement follows:]

STATEMENT OF RICHARD J. SMITH, PRINCIPAL DEPUTY ASSISTANT SECRETARY, BUREAU OF OCEANS AND INTERNATIONAL ENVIRONMENTAL AND SCIENTIFIC AFFAIRS, DEPARTMENT OF STATE

Mr. Chairman, the Department of State appreciates the opportunity to testify before this Subcommittee on foreign policy aspects of the Space Station. In addition to discussing how the Space Station relates to U.S. foreign policy objectives, I would like to describe in general terms the progress that has been made in bringing our allies into the Space Station program and to outline some the issues that may arise when we begin to negotiate agreements governing international participation in the development, operation, and utilization phases of the program.

From the State Department's prespective, the President's manned Space Station initiative has the potential to yield significant foreign policy benefits. U.S. leadership in space has served our country well—both as a symbol of technological prowess and in practical terms. But we cannot stand still if we are to remain in the forefront of space exploration. The Soviet Union is moving ahead with an ambitious space program, and Europe and Japan are developing their independent capabilities. The Space Station is the centerpiece of the U.S. space program for the 1990's, the successor to Gemini, Apollo, and the space shuttle. It is an essential next step if the U.S. is to preserve its leadership in space.

From the outset, we have seen the Space Station program as an opportunity to strengthen our ties with key allies. When, in January 1984, the President committed the U.S. to develop a permanently manned Space Station within a decade, he also invited friends and allies to join with us in this major technological undertaking. We see international participation in this undertaking as a means of enhancing the Space Station's capabilities as well as a highly visible demonstration of the Western allies' commitment to working together for mutual benefit.

The foreign policy dimensions of allied involvement in the program extend beyond the immediate objective of establishing a permanently manned presence in space. The strength of the Western alliance is due in large measure to the power and vigor of Western technology. The Space Station could be a major factor in stimulating further technological advances. Moreover, the arrangements we work out for the Space Station could have a profound and lasting effect on cooperation among the Western industrialized nations, establishing a model for cooperation in large-scale technology projects.

Our allies' response to the President's invitation to participate in the Space Station has been enthusiastic. At the 1984 London Economic Summit, the leaders of the United States, Western Europe, Japan, and Canada agreed that the Space Station is "the kind of programme that provides a stimulus for technological development leading to strengthened economies and improved quality of life." In the spring and summer of 1985, the appropriate Canadian and Japanese science and technology agencies and the European Space Agency (ESA) signed memoranda of understanding with NASA governing their participation in the detailed definition and preliminary design phase (Phase B) of the Space Station program.

At the 1985 Economic Bonn Summit the President expressed his appreciation for these positive responses. The Bonn final communique contained the following section concerning the Space Station:

"We welcome the positive responses of the member states of the European Space Agency (ESA), Canada and Japan to the invitation of the President of the United States to co-operate in the United States Manned Space Station Programme on the basis of a genuine partnership and a fair and appropriate exchange of information, experience and technologies."

NASA, of course, has been heavily engaged in international cooperative activities for years. But none of NASA's hundreds of cooperative programs involving scores of countries compares with the Space Station in scope, duration, or sheer size—or in the significance of the political and financial commitments called for by its foreign partners. Canada, Japan, and Western Europe have already invested millions of dollars in the Phase B preliminary design studies they are conducting in parallel with NASA's studies. This is only the beginning.

All of the international partners have indicated their intent to continue into the development, operation, and utilization phases (Phases C/D and E) of the program, subject of course to successful completion of their design studies, satisfactory negotiation of follow-on agreements, and availability of funds. NASA has already reached agreement with Japan and Canada on the elements they propose to develop. Discussions with ESA are continuing, and we hope a firm agreement will be reached soon. We anticipate that formal decisions to proceed will be made by each of the international partners in the spring of 1987 at the end of the design phase.

Soon—we hope within the next month or so—NASA and State expect to begin negotiating agreements for Phases C/D and E of the Space Station program. These negotiations will not be easy. The cooperative arrangements among the partners promise to be extraordinarily complex. Our partners will want to ensure that their interests are protected. National pride and large sums of money are involved. The Europeans have requested, and we have agreed, to negotiate both 1) a government-to-government agreement to be signed by the U.S. and the European Space Agency member governments and 2) an agency-to-agency agreement to be signed by NASA and ESA. The Japanese and the Canadians are currently considering whether they desire to have similar arrangements or whether an agency-to-agency agreement will suffice. State and NASA are working closely together to prepare for each set of negotiations.

In carrying out these negotiations we may have to explore some uncharted territory. For example, we may find few precedents to guide us in devising:

Principles and guidelines for managing the largest complex put in space by man, crewed by nationals of several different countries;

Arrangements for fair and equitable use of the Space Station's resources and fair and equitable sharing of operational costs;

A legal regime to govern the responsibilities and liabilities of the partners on board the Space Station; and

Rules to protect information and data developed during the design and construction of the Space Station of through use of the experiment modules.

Among the State Department's broad objectives in the negotiations will be:

To ensure that international participation enhances the Space Station;

To ensure that the project strengthens our relations with our allies;

To help devise a framework for international participation that demonstrates the attractiveness of working with the U.S. in space and in other areas of advanced technology;

To prevent adverse technology transfer; and

To ensure that the legal regime governing international cooperation on the Space Station is consistent with U.S. long-term interests in outer space law.

Mr. Chairman, let me summarize where things stand. Technical work on the Space Station is moving ahead briskly. The Japanese, the Canadians, and the Europeans remain enthusiastic about participating in the project. They look forward, as do we, to beginning negotiations soon on the arrangement governing international participation in the development, operation, and utilization of the Space Station. In preparation for these negotiations, State and NASA have already held a number of preliminary talks with the allies, most recently in Paris last week.

Our initial discussions lead us to believe that there will be many difficult issues, but we are confident that the negotiations will succeed. The State Department has been working very closely with NASA and will soon be engaged in intensive consultations with other departments and agencies that have expertise or an interest in some of the issues. We also want to work closely with this and other committees and subcommittees of the Senate and the House, so that the views of Congress will be fully taken into account in the intergovernmental arrangements that emerge from our negotiations. We want the Space Station to be a true partnership that sets new standards for cooperation in large-scale technology, preserves U.S. space leadership, and strengthens the Western alliance.

(The following information was subsequently received for the record:)

QUESTIONS OF SENATOR GORTON AND THE ANSWERS

Question. According to your testimony, the United States and ESA will negotiate a government-to-government agreement, and NASA and ESA will negotiate an agency-to-agency agreement. How will these two agreements differ, and how will they be similar? Why is there a need for two agreements? Why would Japan and Canada consider only an agency-to-agency agreement and not a government-to-government agreement as well?

Answer. The government-to-government agreement with Europe will be an umbrella agreement focussing on broad principles, including the legal regime that will cover the Space Station. It will be signed by the United States and by each member state of the European Space Agency participating in the project. The agency-to-agency m emorandum of understanding will be essentially an implementing agreement covering the programmatic and technical aspects of the cooperative program. It will be signed by NAS and ESA.

The members of the European Space Agency requested that we negotiate two agreements, and we agreed to do so. The Europeans have expressed some concern about the durability of the U.S. commitment to the project and may see a government-to-government agreement as one means of ensuring a heightened U.S. political commitment to see the project through. They may also see some advantages to involving each participating European government in the negotiations directly, rather than indirectly through ESA.

We have not yet been formally advised by Canada or Japan what form of agreement they prefer, but we expect that both will wish to have an government-to-government as well as an agency-to-agency agreement.

Question. 2. If one of the international partners were to withdraw from the space station program over programmatic differences with NASA, how would this affect the nature of the program, and would there be any ramifications beyond the space station program?

Answer. The withdrawal of one or more of our international partners from the Space Station program would detract from the overall capabilities of the Space Station. Each of the partners has already invested millions of dollars in definition and preliminary design studies. Eventually, the U.S. could make up for any capabilities lost, but this presumably would require additional time and money. Such a withdrawal would also have foreign policy ramifications. International cooperation on this project could strengthen our ties with key allies and establish a model for cooperation in future large-scale technology projects. To the extent that the Space Station does not live up to expectations as an international cooperative venture, its foreign policy benefits are likely to be diminished.

Question. 3. According to your testimony, one of the broad objectives of the State Department will be to prevent adverse technology transfer.

What principles will guide you in protecting these interests, and how will the Commerce Department and the Department of Defense figure into this discussion?

Answer. We hope to reach agreement with our partners on technology control provisions that will allow each partner to have access to the technology it needs to design and develop the elements it will contribute to the Space Station and otherwise carry out its responsibilities in the program, while fully protecting proprietary and classified information and guarding against unwarranted transfer of technology to third countries. These provisions must, of course, be in concert with the laws and regulations of the International Traffic in Arms Regulations (ITAR) and the Export Administration Act.

The State Department and NASA will soon be engaged in intensive consultations with other interested departments and agencies, including Defense and Commerce, to develop sound and workable technology control provisions for the Space Station agreements.

Question. 4. You mentioned that there may be few precedents to guide us in shaping the international aspects of the Space Station. Are there, in fact, any precedents which could apply to this program, in particular to the aspects of overall management of the Space Station and sharing of costs and resources?

Answer. So far we have found no precise precedents for the kind of cooperative arrangements that seem appropriate for the Space Station.

Question. 5. Likewise, could you discuss the application of international law to this program and the jurisdictional issues that are likely to surface?

Answer. International law allows us a great deal of flexibility in devising the arrangements that will govern international cooperation in the Space Station program. These arrangements will be fully consistent with international law, including the relevant provisions of the outer space conventions.

We anticipate that the partners will wish to establish a legal regime for the Space Station that is "user-friendly." Such a legal regime should be as uncomplicated as possible, provide maximum predictability, and make sense in practical terms. This presumably will require setting forth in the agreement which party will exercise jurisdiction—either for the Space Station as a whole or for particular elements of the Space Station—with regard to criminal law, tax law, civil causes of action, patent law, etc.

Senator GORTON. Because the chairman has a memorial service he must attend at noon, I am now going to go out of order and ask Ms. Georgia Franklin of the Washington State Citizens for Space to come forward and testify.

Ms. Franklin, we appreciate your coming all the way across the country for this. We have your written statement, which will be included in the record as if read in full, and we would appreciate your summarizing it if you can.

STATEMENT OF GEORGIA FRANKLIN, WASHINGTON STATE CITIZENS FOR SPACE

Ms. FRANKLIN. I appreciate that very much.

It is a delight for me to be here. It is a great honor for me to be here. And I come from way out there in the north country, Seattle, WA, and you know, I would not have come from there this morning if my great-great-grandmother had not walked the Oregon Trail to get to the Great Northwest, that pioneering spirit that has made this country great.

I have heard some pretty fair testimony here this morning. I have read quite a lot of testimony in the last few years about our space program. I am not a technician. I am not a teacher. I am not a scientist. I am an old lady, a housewife from Seattle, WA, who cares about the Space Program. I care about what is happening.

I remember the day that Allan Shepherd went up on that Mercury capsule. Every automobile in Seattle, WA, stood still while we listened to a radio broadcast that said that he had come back down safe. The same thing happened when John Glenn went. The same thing has happened with every shuttle flight until we saw what happened with the *Challenger.*

Now, is that going to deter us? Is that going to hold us back from doing the thing that we need to do? It should not. It ought to make us more determined than ever to take our rightful place in the Space Program. The space station is the most powerful thing that we have going for us. It needs to be built not in 1994, like I heard today. If we put it off until then, it will be off until 1999, 2010. I will never live long enough to see it built if we do not do something positive. Let us quit being so timid. Let us act like the American people that we are, with a little bit of spunk, and get-going and sticktoitiveness to do something powerful and important, not for us, not for the people of my generation, Senator Gorton, not even for the people in your generation, but for our children, for our young generation of scientists, of technicians that are going to school.

We have dangled a carrot out in front of our kids and said this is what we are going to have, it is wonderful, and it is magnificent, and we are going to be living in space. Well, are we? Are we serious about what we are doing? We have heard talk today about a deficit. Certainly it is important. As a taxpayer, I care. Every American cares. We are looking at and asking for $410 million in fiscal year 1986 or 1987 for the space station. It is a drop in the bucket from what we need. We spend dollars for every other conceivable thing in the world except the thing that is going to give us an economy, a resource, a reason for our kids to go to school, a motivation for those children to go into space technology, to give them the opportunity to learn about math, to learn about science, to be able to communicate in writing. The arts, the humanities, every single thing we teach in school can be done better because the Space Program is there. It is an opportunity for them. All they hear is the negative. They hear about drug abuse. They hear about child abuse. They hear about nuclear holocaust. They hear about everything in the world except the positive. We need to give our kids a reason to learn, a reason to be proud Americans, to stand tall and say we are going to do it.

NASA has done a good job. They have been inspirational for the last 25 years. It is our fault they have not done better. The have not been given enough money consistently. Their budget goes down and down and down until now we are thinking about cutting them again. Let us not think about cutting the thing that can be economically sound for this country. Let us think about raising their budget a little bit. $410 million ought to be the bottom line. We should not go down any further than there. We ought to go up. And if we were doing the kind of job that we should do and educate the general public to where we are going in the Space Program, how far behind we are, do you think the American public does not know? We read. We look at newspapers. We watch television programs. We know what is going on, and we care. It is just that maybe we do not care enough to let you know that we care. But I think the time has come when we had better, because we are going downhill. Every generation has left this country a little bit better than it was before. We need to think about that, too. We need to leave our country a little bit better than it was when we came. We are going to do it by giving our young people a brandnew frontier.

You know, a few years ago we dreamed of flying like the eagles. We have, and we do. And we dreamed about walking on the Moon, and we did. And now we dream of living among the stars, and if we do our job, our children will.

Thank you very much.

Senator GORTON. Thank you very much, Mrs. Franklin. One question. At the end of your written testimony you cite figures about various support for our space programs from a poll which the Seattle Times took in the State of Washington. Do you believe that that is an aberration which is located only in one part of the country?

Ms. FRANKLIN. Absolutely not. I think that is nationwide.

Senator GORTON. Thank you very much.

Senator Riegle.

Senator RIEGLE. I just want to thank you for coming. It is a long trip, and you obviously have a very strong feeling which you have expressed well, and I appreciate the fact that you are here, and that as a citizen, that you are making your point of view known to us.

Ms. FRANKLIN. Than, you, sir.

Senator GORTON. Senator Heflin.

Senator HEFLIN. You are the most eloquent spokesperson that I have heard in a good while. I would like to get you down to Alabama.

Ms. FRANKLIN. I would like to come. You know, down there we need to know about the Space Program for my and all grandchildren.

Senator HEFLIN. If you get tired of space, I would like you to start talking about the farmers.

Thank you. You are a great spokesperson.

Senator GORTON. Thank you very much, Mrs. Franklin. We appreciate your being here.

[The statement follows:]

STATEMENT OF THE WASHINGTON STATE CITIZENS FOR SPACE AND THE INTERNATIONAL L-5 SOCIETY

In the middle of the last century, many people risked their lives and livelihoods to explore, develop and settle the Pacific Northwest. 20,000 graves along the Oregon trail testify to the risks they took and of those who didn't make it—but the industrious, beautiful states we have today tell us that despite the risks, more came to settle the wild frontier. They turned desert land into farmland and built industries and shipping ports to Alaska and the Orient, so that today the Northwest, including our home state of Washington, provides homes and livelihoods for millions of people. They gave their children a better world in which to live.

Modern technology has neither dulled our spirit nor quenched our ambition. It has enabled us to once again reach into new frontiers. We mourn the deaths of seven of a new generation of risk-takers: the crew of the shuttle Challenger, who died advancing the important tasks we have given NASA. These tasks are the development of the frontiers of space, and the developments on the frontiers of science and industry that go along with it. While we have criticized NASA for some aspects of its operation, we are proud of what they have accomplished and we believe NASA must have a higher budget and a new commitment if our space program is to continue.

"Christmas is a time when kids tell Santa Claus what they want and adults pay for it. Deficits are when adults tell the government what they want—and their kids pay for it."—Richard Lamm, Governor of Colorado.

In recent years, Congress has grown increasingly concerned with the budget deficit and the steadily growing trade dificit, and rightfully so. Deficits provide the current generation with here and now pleasures and comfort, and leave the responsibility of paying the debt to our children.

The American people abhor the making of our lives easier at our children's expense. Americans have always desired to leave the new generation a world better than the one day they grew up in—and up until now, they have largely succeeded. It is very important that we reduce our massive deficits. The deficit is not our only problem. We must remember that our children will not live on money alone. They need a strong economy, jobs, education, and above all dreams.

So what will our children inherit? Will our gifts be all negative—large deficits, a struggling economy, and the threat of nuclear holocaust? It is time to start concentrating on something positive to give our children; a dream they can hold onto and some resources they can use to make the world better.

"I'd like to leave my children with the idea that dreams can come true, but that you first must be imaginative enough to have dreams."—Judi Missett, owner, Jazzercize.

The space program is one of the biggest resources for our children's future. In education, science and industry, the space program is becoming a resource of practical value and a motivator to even greater endeavor.

Science has made startling breakthroughs by exploring space. The recent Voyager flyby of Uranus provides a vivid example to our children of the positive things science can accomplish. However, photographs are only images; they are not the same thing as being there. The presence of people doing science in space—and yes, teachers teaching from space—inspires our children to learn the science and math that are so crucial in our modern high-tech society.

The best gifts for our children are healthy bodies and a healthy economy. The space program has already helped our own generation with industries like satellite communications and life-saving spinoffs such as telemetry and heart pacemakers. Billions of dollars are poured into our economy every year by the spinoffs and direct benefits of the space progam. Future benefits appear even greater, when industry starts harnessing the unique environments of space.

A space-made drug called erythropoietin is already being tested to treat sufferers of anemia. It could exend and improve the lives of millions of people. Scientists are also studying the production of drugs to treat diabetes, cancer and other deadly and dehabilitating diseases. The current shuttle delay is postponing the day when patients can benefit from these drugs. We must ensure the safest possible environment for our astronauts. At the same time, we do not want to jeoparadize the lives of those people waiting on the results of this research, which can be more quickly and accurately completed in space.

The new industries sprouting up in space include not only pharmaceuticals, but also remote sensing, the retrieval of broken satellites for repair, and the manufacturing of metals, crystals, and other goods that benefit from zero gravity. We have only scratched the surface of new products with the research accomplished so far on Skylab and the shuttle. Fifteen years from now, if we make the investment now, we will be making products that we are totally unaware of today.

The development of space is a step-by-step process, as Washington State Citizens for Space described in detailed testimony presented to the National Commission on Space last November. The prerequisitite to doing more in space is the ability to launch people and machines from earth. The recent loss of the Challenger not only requires that we build at least one more shuttle as a replacement, but that we research methods with which to build a cheaper, safer second-generation shuttle. Had we started such research several years ago, we might be in a position now to go ahead with the new project instead of building replacement shuttles. We are still in a very early phase of this research, so we do not have that option.

The recent disaster also highlights the fact that the shuttles were built to be a transportation system to and from space, not full-fledged space platforms in their own right. Using shuttles as working platforms in space makes about as much sense as towing oil rigs out to sea and back to port every week. The top priority of this nation's space development endeavor must remain its permanent working platform in space, the space station.

While the space station is not without its own hazards, it will enable crews to live in space for many months without having to keep taking trips up and down in the shuttle. All space fatalities to date, and undoubtedly most in the future, involve flight or preparation for flight through the atmosphere. Just as taking off and landing are the most dangerous parts of air travel, transportation to and from the earth is the most dangerous part of space travel. The station, if used properly, can maximize the number of people working in space while minimizing their risk.

The crews aboard the station will work with technology to produce results that neither man nor machine could accomplish alone. Observers from the station give remote sensing a boost by pointing our interesting spots on earth at which to look. They can also make observations not possible with remotely controlled cameras. Astronaut and oceanogarpher Sculley-Powers was able to observe ocean features from a recent shuttle flight that photographs have never been able to capture; this has led to the rewriting of oceanography textbooks. The Soviet Union, which has had their own small, manned stations for over a decade, has effectively used human observation to spot good fishing grounds and to coordinate military exercises.

Vehicles flying from the station will make satellite retrieval an on-demand operation (not restricted to shuttle availability). Facilities too large for the shuttle to carry at once will be available on the station to repair satellites that would otherwise have to be brought back to earth and relaunched. Servicing satellites on the ground is like sending your car back to Detroit to get the oil changed.

The presence of people aboard the space station will allow us to build large structures, such as radiotelescopes, communications platforms, and other facilities that will greatly improve our space science and industrial efforts.

Our current shuttle fleet has provided much valuable research. It must be realized, however, that the amount of man-hours and research that can be accomplished on short, expensive shuttle flights is very small compared to what can be done on the station.

All these breakthroughs provide America with what it needs the most: an influx of new industries. Many of our older industries, such as steel, autos, forestry, electronics and even to some extent computers are being taken over by those countries who are able to use cheaper labor. If we want to be able to compete without cutting our own paychecks, we must leapfrog ahead of the competition. We must produce something that they can't. The space station, and the industries it spawns, are a very good way to do that. The birth of these industries means jobs at high wages, not only at companies like Boeing but also at the new companies that are forming, such as Space Industries, Astrotech, Spacehab, and many others. The space station is an investment that is cheaper to continue than to cut.

The jobs the station's crew can perform will give space scientists new capabilities and dramatically improve old ones. Currently a small but loud group of space scientists are criticizing the space station because, they claim, it will take money away from space science. They are making two very false assumptions. The first is that space science is the only important thing we're doing in space. In fact, space science is only one part of our civilian space endeavor. NASA's tasks also include the study of materials and living things (such as humans) in the space environment, the observation of our own planet, and the most immediately important endeavor, the creation and improvement of industries that make our country strong. The second false assumption is that space science is a static thing that will always be done with instrument platforms. In fact, experiences from Apollo and breakdown of Solar Max show that fully automated space science is woefully primitive compared to what can be done when humans are present. The pictures and discoveries of Viking and Voyager, while spectacular, are practically nothing compared to what human crews could have accomplished. Brad Smith, the head of the Voyager imaging team, expressed his wish that there had been a person aboard Voyager to point the camera at newly discovered objects. We were only able to take those pictures that were preprogrammed into the computer. We declare that there is a need for both manned and unmanned endeavors.

The space station, and the jobs and scientific knowledge it could create, are in grave danger of being cut. The Gramm-Rudman bill is being targeted by some unfairly at NASA. NASA's budget, less than one percent of the Federal budget, pales in comparison to the practical benefits NASA has given us and the dreams it has inspired. The proposed $200 million cut in space station funding is unacceptable. Station funding must be authorized for $410 million for fiscal year 1987.

Many years ago, NASA outlined an excellent plan for a space station, and it is the Soviets who are carrying it out. Delaying the space station would mean breaking our promises to our European partners in the project. It would mean turning our backs on President Reagan's 1984 directive build the permanently manned space station "within a decade." Worst of all, it would mean delaying or eliminating the benefits to ourselves and our children.

The Office of Management and Budget has proposed a delay in the program until 1997. Such a severe slip would seriously damage the project, reduce the efficiency of NASA centers, harm the U.S. internationally and thwart initiatives to draw in more commercial space investment. We urge the station be completed in 1992 as originally scheduled. With completion in 1992, we can triumphantly celebrate the 500th anniversary of Columbus' discovery of the New World.

In the last twenty years, the NASA budget has declined dramatically, from five percent of the federal budget in 1965 to around three-fourths of one percent today. We dream of a space station, while the Soviets build one. We watch Comet Halley from the ground, while other nations send emmisaries. Our space program is in crisis, and it is up to Congress to rescue it.

Our responsibility as a nation is to lead the rest of the world into space, not to follow. If you do not believe this, ask the young people of America. There is a surge of enthusiasm for space exploration among our youth. Where are the John F. Kennedy's of today who will boldly say, "space is the new ocean, and we must sail on it"?

According to a recent Seattle Times poll, 89% of the citizens of Washington State want our nation's space flights to continue, and 40% say we're ready to go ourselves. The people of America do care about our children. We want to leave them a world better than the one we grew up in. We want to cut the deficits for our children, not at the expense of our children. One of the greatest gifts we can give the generation now growing up is a new frontier—the frontier of space.

Senator GORTON. Now, Drs. Black and Hudson. Dr. Black, you may proceed. As is the case with the other witnesses, your written statement will be included in the record as if read in full, and we appreciate your summarizing your testimony.

STATEMENTS OF DR. DAVID C. BLACK, CHIEF SCIENTIST, OFFICE OF SPACE STATION, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION; AND DR. HUGH S. HUDSON, RESEARCH PHYSICIST, CENTER FOR ASTROPHYSICS AND SPACE SCIENCE

Dr. BLACK. Thank you, Mr. Chairman and distinguished members of the subcommittee, and let me first comment on a question that was raised earlier when Mr. Hodge was here. One of the members asked a question concerning the number of materials experiments that the Soviets have had relative to that of the United States, and the number as I understand it is something like 1,500 to 1,600 for the Soviets and something like 100 for the United States, so it is not quite as bad a ratio as the 3 that was indicated before.

Another comment I would like to make also with regard to the question that was asked of Mr. Hodge in terms of the pace of putting the facility together, Dr. Hudson and I are here on behalf of the users, the space science community in particular, and one point, I think, that is important to bear in mind is, it is not just putting a facility in space, that is, just putting the hardware there.

One has to keep in mind that it is to be used intelligently, and if we look at the pace of developing the instrumentation to make good use of this facility, we would have to essentially turn off, I believe, most of the current space science funding or redirect it and focus it entirely in terms of the space science activities that might use the space station if we were to try and match a faster pace, and so I think there is a reasonable match in terms of the long lead programmatic time scales for the use, intelligent use of the facility as well as the development of the facility.

With those remarks, I might just say that as I indicated in my testimony, when I was first asked if I would come back and do this job, I had some misgivings. The space science community, as you are aware, has had mixed success in some sense in interacting with the manned program in the past, and one of the things that was very inspirational in terms of my accepting this job was in talking with upper level management. In the program here there was very clear evidence that they are extremely sincere and supportive of the user communities in this exercise. It is something which I do not think any of us have seen previously in any major manned activities, and I think it is important for that recognition to be heard.

The community, I think it is fair to say, that is, the space science community appreciates that not everything we want to see will be done. There are certain things that for a number of good reasons will not be possible to do, and I think the sense is that as long as we have a good day in court, if you will, that is the important thing, and I believe that that is occurring.

As we look to the future, I think it is important that we maintain very visible and critical oversight function of an independent type such as the task force that Hugh and I are members of. I would hope then that the sons and daughters of Task Force on the Scientific Uses of Space Station (TFSUSS), whatever those committees might be, would be things that we could see. I would hate to see the TFSUSS end as a function, and it does officially end this fall, but I think it is important that that kind of function be carried on in some way.

There is, I think, a growing recognition amongst the science community that the space station signals really the dawn of a new era in space science. Traditionally, the space sciences, that is, astrophysics and planetary science, which are my two areas of interest, solar, the usual, the so-called classical space science endeavors, are in the main observational disciplines. They are really not true experimental disciplines in the sense that we are used to in a terrestrial laboratory, and what the space station will bring to the table is the opportunity for the first time to really engage in true experimental activity in space.

It is an expansion of the space science activity to a broader sense, what the task force has referred to as science in space, and I think that is an important aspect to bear in mind. In my year in working with the program as the chief scientist, it has become fairly clear to me that one of the crucial aspects of the success of the space station is not going to be the hardware. I think we will, whether in its full glory as depicted in the model here or something somewhat more modest, we will really have good, usable hardware.

To my mind, the key to the success of this facility is going to be in the operations. One of the things that we really must do is find some way to facilitate rapid and economical access to the space station, economical and rapid enough so that it now is attractive to the large number of very capable university scientists and their graduate students who heretofore have remained away from manned space flight and the kind of capability that manned space flight has potential to bring for research.

And I think we must somehow find a way as we look to the future in the operation of the space station to turn that around. Also, I think it is important that we strive in terms of the onboard operational aspects to achieve as much flexibility as we possibly can. We have to have an environment which mimics as closely as possible, given, of course, the safety considerations, which are always paramount, the kind of situation that we have in the terrestrial laboratory. We have to have that flexibility to truly capture this new capability that I think the space station will provide.

Finally, Mr. Chairman, I would just remark that I think that we have to recognize the importance of evolution as we look to the space station. This is, after all, the first permanently manned capability after the Soviets', which apparently will be there before ours, and we are really to a first approximation fairly ignorant of how to live and work in space. We have had some experience, but really not all that much when you add up the total number of flight hours. In fact, the Soviets have had something like twice the number of flight hours that we have had.

As we learn from the early station, the one that will be there in 1994, and we will learn from that, and I think it is important that we be able to implement that learning in a very effectively and timely and planned way. There is no question that I think that the agency, NASA, and the Nation need to recognize that humankind is beginning, in a modest way, to be sure, a profound and irreversible change in the way we use space. I think a part of that recognition is to develop a long-range plan and commitment to fully utilize that capability.

Thank you, Mr. Chairman.

[The statement follows:]

STATEMENT OF DAVID C. BLACK, CHIEF SCIENTIST, OFFICE OF SPACE STATION, NASA

Mr. Chairman and Distinguished Members of the Subcommittee:

Thank you for this opportunity to discuss with you the Space Station program, its utility for the conduct of science as well as the concerns which the science and applications communities have as potential users of the Station.

At the outset let me express my belief that the Space Station--both the manned base and its associated free-flying platforms--will represent a unique and highly useful capability for scientific inquiry. Properly conceived, the Space Station will be a valuable national asset, one that contributes significantly to the nation's research base while clearly challenging our intellectual ingenuity and technical skills.

As Chief Scientist my responsibility is to ensure that the Space Station program provides capabilities that are both useful and affordable to the scientific and applications communities. Because of the work of many, we have made a strong start in achieving this goal.

Perhaps I should comment briefly on this responsibility and on the background leading to my becoming the Chief Scientist. In 1983 I was a member of the Space and Earth Science Advisory Committee (SESAC) of the NASA Office Of Space Science and Applications. There was growing interest in and concern about the Space Station Program expressed by the SESAC, concern primarily that the Space Station would be built but that there might be relatively little input from the science and applications communities with regard to Space Station requirements, design and operations. As a consequence of those concerns a special SESAC Task Force on Scientific Uses of Space Station (TFSUSS) was established in early 1984 under the chairmanship of Professor Peter Banks of Stanford University. I was a member of the original TFSUSS and continue to be a member. However, as you have written testimony from Professor Banks, and you also have testimony today from fellow TFSUSS member Dr. Hugh Hudson, I will not comment specifically on recent TFSUSS activities. I would point out though that one of the early recommendations by the TFSUSS was that the Office of Space Station establish the position of Chief Scientist. It was felt that this position should be filled by a working member of the science community, and that it should have direct access to the Associate Administrator for Space Station. The position was established, and early in 1985, I was asked by Philip E. Culbertson, NASA's Associate Administrator for Space Station at that time, if I would be willing to serve as the first Chief Scientist for Space Station. I accepted and began my appointment in April of 1985, with direct access to the Associate Administrator.

A major concern of all potential users of the Space Station is that any requirements they might place on the Station be recognized and, where reasonable, be accommodated in the Station design. This concern is prompted mainly by experience with previous manned space programs. In those cases, systems were designed and then presented to the users; there was little or no significant involvement by the prospective user communities in the design process.

The Space Station Program has not repeated this procedure. In my view, it has been fully responsive, early on, to the needs and requirements of the wide range of user communities. Let me offer two concrete examples. The first deals with the subject of Space Station configuration. The Space Station Program began its Phase B studies in April of 1985 based upon a reference configuration for the Space Station. As a consequence of an orderly set of reviews within the program, reviews directed at critically re- examining the concept set forward in the reference configuration, many key aspects of that configuration were either changed or eliminated. These actions were in nearly all instances taken in response to user input. Specific examples of these changes are (1) the choice of atmospheric pressure and composition in the laboratory and habitation modules, (2) the decision to outfit modules on orbit thereby permitting launch of larger volume modules over what would have been possible if the modules were outfitted on the ground (as is the case with the Spacelab system), (3) changing the module connection pattern from the original "race track" pattern where the module interconnects took up valuable laboratory or habitation volume, to one in which the interconnects are external to the modules and thus provide maximum module volume for the users, (4) location of the modules closer to the center of mass of the Space Station in order to provide the lowest possible level of acceleration in the laboratory modules, and (5) a decision to produce a modular platform which will serve a wide variety of users. This list is not intended to be exhaustive, but to indicate some of the major programmatic and design changes that have occurred because of user requirements.

It should be noted that these decisions were not always easily achieved. There was, for example, considerable debate on the question of the atmospheric pressure and the composition for the pressurized modules. The science and applications communities wanted standard atmospheric pressure and composition, whereas the operational elements within the program preferred a lower pressure and a composition which was oxygen-rich relative to the air in this room. The result of the debate was to chose the option recommended by the users.

I am unaware of any instances in which the requirements of the user community in general and the science and applications community in particular has not been adequately considered and incorporated into the current definition and preliminary design activities. The reasons for this success are varied. Certainly, the TFSUSS has had a very positive effect on much of what has occurred. Also, the advocacy positions for Commercial, Scientific, and Technological user communities that exists within the Utilization Division of the Office of Space Station have proven to be very effective. Finally, and perhaps most significantly, I have found that there is a deep and real commitment within the NASA Office of Space Station to meet the requirements of the users. This has led to a healthy give and take on both sides of the fence and I believe that the "builders" are now fully aware of and responsive to the requirements of the user communities. In return, there is a better appreciation by the users of the difficulties and concerns facing the Space Station designers.

The second example concerns the incorporation of platforms into the Space Station design. These platforms will be unmanned and fly in both co-orbiting and polar orbits. The platforms with the Station base represent a commitment by NASA and the Space Station Program to the user communities. As a part of the overall Space Station Program, they are extremely valuable. The science and applications communities have done considerable planning to fully utilize the capabilities offered by these Station platforms. NOAA and our international partners have expressed considerable interest in them. The Space Station Program in NASA has steadfastly retained its commitment to these platforms.

Although the requirements of the users have been incorporated in most of the current Space Station definition activity and the platforms have become an integral part of the Space Station Program, there remains concern that once the Program enters into the design and development phase (Phase C/D), the interests of the users will be among the first to be sacrificed if there should be budgetary problems. Fortunately, the Space Station Office is as concerned about this as I am. A number of steps can be taken to assure this does not happen.

First, I believe it is important to maintain a group like the TFSUSS during the upcoming Space Station preliminary design and Phase C/D activities. The TFSUSS currently ceases to exist in the fall of 1986. In this regard, the Office of Space Station will work with the Office of Space Science and Applications to establish the foundation and functions of a "next generation" TFSUSS.

The Office of Space Station also should continue the function of Chief Scientist, as I believe it will. I believe that this position is an important one in that it provides direct access to, and an awareness of all major decisions within the Program. I have had every opportunity to raise an issue on behalf of the science and applications communities. The position of Chief Scientist helps ensure that the interests of science and applications are addressed on a continuing basis.

Beyond these two formal activities on the part of the Space Station Program, I believe that an effective mechanism to assure continued promotion of user requirements is for the user communities to maintain a strong interest in the Space Station. This interest must be supplemented by an active interest in Space Station on the part of NASA's Office of Space Science and Applications. The Office of Space Science and Applications has established an internal organization to define and promote its interests in Space Station, an activity that must continue and, become more vigorous as we enter preliminary design.

If one looks beyond the Phase C/D design and development activity towards the operational phase of Space Station, I see two areas in which the Space Station Program is and must continue to be sensitive to enhancing the utilization of Station capabilities. One of these areas is that of operations and the second is that of evolution. Let me comment briefly on each of these.

To have an effective research facility, be it 250 miles above or simply 250 miles along the surface of the Earth from Washington, it must provide relatively inexpensive and rapid access to its resources, as well as have operational policies that permit adequate flexiblity in procedures. I have been asked by the Associate Administrator for Space Station to examine how the Space Station can provide such an operational environment, one that is conducive to high-quality research in space, but can be utilized relatively simply and without enormous financial resources. I am about to initiate that study by assembling a small group of individuals from both the scientific and commercial communities to determine the characteristics that are required from an operations point of view in order for these goals to be realized. Also involved will be people with first-hand knowledge of what we can learn from our experience with operations on the Space Shuttle.

The Space Station Program recognizes that the nation is facing budgetary constraints. It is generally felt by the science and applications users that it would be better for the Space Station Program to maintain schedule, even if the capability to be delivered in 1994 is somewhat less than originally considered, than to delay the program. Our experience with the Space Shuttle wherein there were major delays and loss of opportunities for a number of scientific groups because of those schedule delays reinforces the belief that this is not an experience we wish to repeat.

However, there is also a strong requirement from the user communities that the Space Station Program put in place a reasoned plan for Space Station evolution to permit realization of a fuller capability to meet requirements as rapidly as is fiscally prudent. The Office of Space Station has initiated a modest effort to carefully examine the issue of Space Station evolution. It is my belief that this activity, which involves users as well as designers, is one of the best ways to assure that the program, in the long run, is responsive to the long-term requirements of the user communities.

This brings me to the end of my written statement, Mr. Chairman. I would be happy at this time to answer any questions that you and Committee members might have.

Senator GORTON. Thank you, Dr. Black.

Dr. Hudson.

Dr. HUDSON. Mr. Chairman and distinguished members, I would like to thank you for the invitation, which was sort of a last minute thing. I am a substitute for Peter Banks, who is the chairman of the task force for scientific use of the space station. And he and I are both university scientists. I am an astrophysicist, a solar physicist specifically. In your letter of invitation you asked several specific questions, and so I thought I would answer those directly and then make a few additional brief comments.

So, the first question was, has the Space Station Program adequately accommodated the relevant and necessary scientific and application requirements? I think the answer to that really has to be yes, emphatically. Through this mechanism of our task force and others, I believe that NASA has been very responsive in trying to ensure that the design of the space station adequately reflects what we think we should do and can do in many disciplines of space research or science in space.

To extend that point one comment further, I hope that the input continues over the next few years, up until the actual launch of the first, or right through the development of the space station, which I hope will continue long beyond 1994, and in that there is continued scientific and user input into the configuration.

The second question was, how would you assess the NASA Space Science and Application Programs relative to their support of scientific and applications use of the space station? I found this question a little bit strange, because it sounds as though it is phrased in a backward sense. There is an existing space program, not only in these classical disciplines that Dave and I represent, but also in the new fields of microgravity research, and there are vehicles in which the spacelab and the use of the orbiter, in which these disciplines can be pursued, and there are plans, well laid out plans and priorities for doing experiments and building the knowledge base, so rather, I think the question should be put the other way around. How does the Space Station Program respond to these program needs in the user communities, and as I responded in answer to the first question, I think that is working out quite well.

The third question, what will be the likely effect on the Space Station Program due to the constrained space launch capability we face for the next several years, I cannot say much about the space station itself. I think we have heard adequate testimony about that. As far as the science and applications programs are concerned, there is no question that there is a serious impact, and in fact there was a serious impact before due to the sluggish start of the orbiter flights.

This is only a speculation, but I am hoping, I say here on the record, that if expendable launch vehicles can perhaps take over some of the load for launching scientific satellites, then perhaps the congestion in the space shuttle launch capability will not be so severe in 3 or 4 years' time, but in the interim it is going to be quite difficult.

I just wanted to add one or two more comments about the management of the space station itself. Senator Riegle was concerned about the international control or the structure by which we would operate the space station. From the scientific point of view it is a little bit easier to think about the space station. I am talking about basic research, because there is a common natural law that governs what it is that we want to do, and by we, I mean the scientists in general throughout the world.

And so it is still a very difficult problem of managing what experiments to do and how to carry out the conduct of these experiments, but in principle we are all interested in sort of the same thing, which is to learn about the universe that we live in and the physics of the thing and the chemistry of the things that we are dealing with, and so I hope that the problems can be, at least at that end of the use of the space station, can be handled in a rational way. And I see that the task force and successor organizations that will help NASA in this country and corresponding scientists and user groups in the partner nations as helping extensively in laying the groundwork for making that work out smoothly.

Thank you. That is basically what I wanted to say.

I should say that in my written statement I have appended the comments that Peter Banks made in his testimony before the House Subcommittee on Space Science and Applications, April 9, which includes the conclusions from our summary study report of the TFSUSS.

[The statement follows:]

Statement of

Hugh S. Hudson
Center for Astrophysics and Space Sciences
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Mr. Chairman and distinguished members of the subcommittee: By way of introduction, I am an astrophysicist from the University of California, San Diego, and a member of the NASA Task Force on Scientific Uses of the Space Station. The chairman of the Task Force, Peter Banks, regrets that he cannot be here himself.

Your invitation to me asked several specific questions. I will try to answer these, but I will also call your attention to Prof. Banks' written statement for the House Subcommittee on Space Science and Applications (April 9); I am attaching a copy of this along with the summary chapter from the August, 1985 Summer Study.

Has the Space Station Program adequately accommodated the relevant and necessary scientific and applications requirements? The answer to this question would have to be "yes;" in my opinion NASA has been responsive to its potential user community in the design process thus far; given this positive attitude, there are grounds for a feeling of confidence that the Space Station will be a useful addition to our capability to do "science in space."

How would you assess the NASA Space Science and Application programs relative to their support of scientific and applications use of the space station?" This question at first sounds rather backwards, since the development of the infrastructure in space should really aim at meeting the needs of the science and applications program, instead of the other way around. I think there will be no problem in most disciplines in putting the Space Station to good use, but not if the science and applications disciplines do not get sufficient support. We have a mechanism - Spacelab - for developing experiments even in the essentially new areas of "microgravity research." The problem, as I discuss further below, is in trying to make a smooth transition into the Space Station era by encouraging experimentation with the present facilities.

What will be the likely effect on the Space Station program due to the constrained space launch capability we face for the next several years? I cannot comment on the Space Station itself. As for the science and applications programs, the slow-down is certainly impeding the proper development of experience on Spacelab. We are also seeing many launchings of scientific satellites being postponed. On the other hand, one can speculate that if NASA returned to expendable launch vehicles for some purposes then perhaps the impact will not be so great in three or four years.

I am now going to make some further remarks on the future of the Space Station program from the point of view of science, emphasizing three questions: what is the role of the Space Station in the evolution of our national program for science in space, how does the development of the Space Station compare with the space development plans of the other "space-faring nations," and how can we best manage the science and applications uses of the Space Station?

It is easiest to discuss the first two of these points together - the need for a space station development and a comparison of the approaches of the non-U.S. space programs. The U.S. manned space-flight program, of course, reached a high level of accomplishment many years ago with Apollo, one fruit of which was the Skylab space station. It is interesting to compare Skylab with Mir, the new Soviet space station - they seem to be roughly similar. From the point of view of planning, though, Mir seems to be much better, since it is obvious that the Soviet government has made their orbiting laboratories a permanent fixture in their overall program. The Soviet progam has built slowly and deliberately to its present state of great success, whereas the U.S. program seems to undergo drastic variations that must be wasteful of effort. I think that the message here is very clear: orderly planning works better.

In principle a manned space station can and will benefit most branches of science in space. The central concern for orderly planning is to see to it that these benefits arrive on a schedule that matches the perceived scientific needs. Unfortunately for this, the novel Space Station resources give us a chance to do new kinds of science and applications well. On the bright side, of course, these new kinds of science may produce discoveries that will rival those of the earlier stages of space research, such as the existence of the Van Allen belts. Free access to laboratories at low gravity obviously make it possible to do all kinds of materials research and life science that had heretofore been impossible - but these are not astrophysics, "space plasma physics," planetary exploration, or Earth sensing, the previous main beneficiaries our scientific space program. Therefore it may be that some of the uncertainty in Space Station development among scientists largely reflects a suspicion that as new disciplines are created, old ones will be forced to shrink just as they are becoming interesting and productive.

How can we strengthen these new science programs in a way that does not impact the "classical" fields of space research adversely? Again, I see orderly planning as the answer. We must insist that science and applications programs smoothly evolve so that we are not unprepared for a sudden installation of new facilities. This seems to mean an emphasis on Spacelab scientific use - and perhaps a partial return to expendable launch vehicles - in the intervening years, plus a readiness to develop the Space Station incrementally. To return briefly to the Russians, it seems to me that the Space Station capability is in about the right proportion to the Mir capability to represent a smooth evolution, so that it may be that our flips and flops and the Russian steady progress will have brought us to about the same point in ten years' time.

My final comments deal with the third major concern, that of management of the Space Station science and applications. There are several thorny aspects to this problem. First, the Space Station and its associated platforms will be very versatile and will serve uses of an enormous variety - Spacelab is a good model here, but it should be far busier still in the future as capabilities grow and experience accumulates. Second, the science and applications uses are international as will be the Space Station itself, and therefore the management of these uses will also have to be international. Third, the spectrum of uses is broad in yet another sense, namely that basic science, applied science, and industrial users must share the Space Station. Even not considering the possibility of defense needs, it is clear that many different "tribal customs" are involved in these widely different communities.

In basic science the problems may not be too severe, but we must work hard to make sure that there is no confusion. The U.S. astrophysicists, for example, enjoy excellent links with Canadian, European and Japanese colleagues, and there is a spirit of unity in the effort to understand the nature of the phenomena that we see elsewhere in the universe. In other fields this internationalism does not seem to be so advanced, but presumably it is now developing rapidly in anticipation of Space Station use.

The Task Force has taken the first steps towards identifying these problems of the international scope of the Space Station. I believe that it is crucially important for the scientists to act now to develop an international voice, analogous to that of the Task Force here in this country, to continue the user guidance of the Space Station program during the critical period when hard decisions will have to be made about the schedule for Space Station facility development.

In summary, it's my feeling that the Space Station development program is approximately on course, but we must see to it that there is a smooth transition between our current methods for doing science in space and the new ones. I hope that scientists of all participating nations can be as influential as we think we have been in guiding the Space Station development, because indeed most of the scientific rewards benefit all mankind.

I would like to thank you for the opportunity to appear before the Subcommittee.

Senator GORTON. Both of you indicated the importance of NASA conducting a sufficient amount of manned space science research before the initial deployment of a space station. Are we going to be able to engage in that research to a sufficient degree by reason of the suspension of shuttle flights and constrained launch capability before the program dates of the space station?

Dr. BLACK. It certainly will make it a little more difficult to get the data base we need. I think until we have a full understanding of the extent of the delay that is going to come about as a result of the consequence of this, it will be difficult to assess the severity of that impact. If we assume for the moment and for the purpose of discussion a 1-year delay, then I think that it will certainly be difficult, not so much that there would not be ample time to get the experience, but with the crowding and the difficulties in terms of priorities that will be there.

The only way I could see that we could keep our schedule to get that data would be to make sure that the space science flights have a little higher priority than they seem to have had in the past.

Senator GORTON. Dr. Hudson.

Dr. HUDSON. I agree, of course. The direct answer has to be no, because there are many experiments waiting to be done, and we have—I believe that the spacelab and the orbiter science in and around the orbiter and some satellites launched from the orbiter, that has been very productive, and it is just a shame that we have to interrupt the productivity.

Senator GORTON. Dr. Hudson, your task force's report expresses concern about the infrequency of anticipated space shuttle polar missions which would enable servicing of polar platforms. Does that concern already anticipate the loss of capability due to the loss of the *Challenger*, or is it simply going to be increased and exacerbated by that accident?

Dr. HUDSON. I do not know if the *Challenger*—I guess my speculation would be that one orbiter would be based on the west coast essentially, and so there perhaps would not be so much of an impact on the access to polar orbit as there would the equatorial orbit. But one of the reasons for the problem is that there should be multiple platforms in polar orbit, because each of these platforms has to be in a different hour ascent local time. And so one flight of the orbiter cannot make it two separate orbits, so if one imagines three or four users in different disciplines of polar orbit, which I think is very attractive, not just for Earth observations but for solar terrestrial physics and even for astrophysics, then it is a long time between chances for the orbiters to service the platforms there. So I think what it probably boils down to is that the instruments that are put on those platforms will have to be designed for long intervals with no access to servicing.

Senator GORTON. Do the two of you believe that we can go ahead with the Space Station Program without a replacement orbiter?

Dr. BLACK. It will be difficult. We think we can go ahead, but I think as was already remarked earlier this morning, there will be delays, and the effort will be spread out in some way, and it will necessarily bring conflicts with other nonspace station uses, and so I think we can proceed, but it would be extremely difficult.

Dr. HUDSON. I concur.

Senator GORTON. Both of you indicated a preference for proceeding directly to a permanent manned capability rather than pausing for some period of time in a man-tended capability. To what extent will space station space science be compromised in that man-tended mode, and would space station space science be enhanced in any way by a man-tended mode? Would there be some ways in which we would learn more rather than less?

Dr. BLACK. I think—let me try and answer that by pointing out that the space station really is not just command component, but in fact as we view it it is an infrastructure which consists of two unmanned platforms from the United States and platforms from our potential partners. Clearly, the platforms will not be affected whether we are man-tended or unmanned except insofar as there will be servicing of those platforms which would be what we call coorbiting with the manned facility.

The attached payloads which you see depicted on the structure to some approximation can also operate in the absence of man. There are some of the solar experiments, and Hugh is better able to speak to these, that might warrant man there in terms of some of their observational programs, but in the main I think it is fair to say that many of the attached payloads would not need man there.

The point I would come back to is the one that I tried to make in my opening remarks, and that is that the real excitement in some sense that I see the space station bringing is the opening of a new type of discipline to space, and that is the real research, experimental, laboratory type of research. And it is quite clear that the vast abundance of that sort of thing which includes the material science work at the forefront would be severely limited by a man-tended approach.

Dr. HUDSON. The way I see it, the space station brings quantity as opposed to quality of access to space in the sense that we can already go up in the shuttle and do experiments with people there. That has been productive. But the new dimension that it brings is the chance to repeat the experiment. Experiments never go right the first time. You have to tinker with them. And to the extent that we can extend that laboratory type of atmosphere into space in a realistic way, the space station may produce wonders in productivity. And so I think I see the man-tended option as kind of—well, for another point, too, to make a station man-tendable, you have to design it to be comfortable for human beings, and so I do not quite see the savings in doing the man-tended option.

Dr. BLACK. May I add just one comment if I may, Mr. Chairman? There has been a lot of discussion about the role of man in space, particularly with regard to automation and robotics as a potential replacement or at least a complement to that capability, and I think it is fairly clear that you can automate successfully production type of activities, and I would hope that that is something that we would see in the future. But for several reasons, I think, and I have worked in a laboratory and done experimental work, no one has yet been able to find a good way to automate the kind of creative things that go on when people do true experimental basic research, and that is the thing which I think the man-tended mode would most severely hamper.

Senator GORTON. Dr. Black, the task force once again has supported the development of an extended duration orbiter which would extend on orbit stay time to 16 days. It has been the position of NASA that the cost of modifying an orbiter to achieve this additional capability would outweigh the benefits. Is that still the NASA position, or is NASA giving the concept additional consideration?

Dr. BLACK. Mr. Chairman, I am not sure what the NASA official position is at this time with regard to the EDO. I do know that it is being looked at carefully at the present time by the Office of Space Science and Applications to examine the kinds of capabilities that would arise if we did have the EDO, and then to look at it, it should be remarked that many of the early cost figures that were discussed by NASA in fact now have been revised downwards, it is my understanding. I think the costs actually are rather uncertain, and so it is difficult to say that costs would not be recovered in terms of the fruitfulness of having that extended on orbit time, but OSSA is in fact undertaking a study to examine this.

Senator GORTON. Dr. Hudson, for the past 2 years the task force has encouraged NASA to develop a telescience link between the space station and ground station investigators. Is NASA giving adequate attention to this technology?

Dr. HUDSON. I believe so, although I have to say that it is a murky business, the whole understanding, the technology of information, transmission and access to control. It is a very complicated technology, but I think basically telescience is the way that we have carried out the classical fields of space research.

Automatic instrumentation has to have been developed. The Voyager in deep space has to have a lot of engineering work done on it even at the present time. Mainly it is a question of giving access to these tools by the new disciplines.

I think as far as I can tell NASA is taking the right steps with respect to the space station by setting up test programs in which universities and other community groups are being asked to practice doing the techniques of space telescience. So I think, from what I can tell, things are on an even keel there.

Senator GORTON. Dr. Black, do you share the enthusiasm of the task force for telescience technologies, and moreover, can they be afforded and now within our budget for the space station?

Dr. BLACK. Yes, I do. I think the answer is yes. I would also point out that I believe it is more than just a matter of technology. It is really that it is a matter of methodology in some sense. It is not simply remote access to data and that sort of interaction.

Telescience, as it has been put forward by the task force, is really a new way of interacting with data coming back from space. It includes the cognitive aspects to try and learn and get something out of the data as well.

So it is a little different step than that, but I think the technology is there, and I think it is affordable.

Senator GORTON. Senator Riegle.

Senator RIEGLE. Thank you, Mr. Chairman. I know you must leave soon for a memorial service that is being held.

Senator GORTON. If you would finish up, I would appreciate it.

I am going to give you each some questions for the record that fill in some gaps in the discussion that has just taken place and in some cases overlap it a little bit. So I am going to have you answer for the record so that we can have sort of a coherent flow of discussion on some of these points.

Senator **Riegle** [presiding]. I would like to impose an entirely different kind of question to both of you here. You both made a very serious professional decision to vote your key years of your working life to what you are doing, one in full-fledged public service.

Dr. Hudson, you are on the university side, but that is as sort of a public service endeavor, too, in its own way, but you have both devoted yourselves to spending the key part of your professional work life in this area. I admire that kind of a commitment, and it is very important that people like yourselves do these jobs. You are obviously drawn to it. You have a love for it and a fascination toward it and so forth. So it is obviously something that must give you very substantial psychic rewards and meanings to each of you.

I would like you to just try in plain language to describe a little more fully, each of you, one after the other, what this really means in terms of taking this next step going to the space station and what that connects us to in what is likely to come beyond that.

You both in different ways have said that we are crossing a line and we are beginning a new chapter or something very fundamental. We are stepping away from what we have done before, and we are stepping into something that is really new and different. I would like to hear you elaborate on that in ways that would really have some meaning for just the people of the country who have to pay the bill for this.

What does it mean? If we follow through and get it done and so forth, what does this station open up and what is this new step? Where are we taking ourselves as a society and as a nation by doing this?

Dr. **Black**. As I tried to indicate, I think in terms of starting first with the science and the commercial aspects, it is really opening up some new horizons. I think that what I have been amazed to see as I have been working with very knowledgeable scientists and commercial people is that it is very difficult to imagine the full capability that this thing will bring to us.

We are not used to thinking about how we would work and take advantage of that environment. I firmly believe that it will take us a little bit of time to have people pump through the system, if you will, to get the experience and go back to the universities and interact with students until we really learn what that capability will fully bring to us.

So I think there is going to be a learning time, as there often is, when there is a new capability, a new frontier that has been opened to people.

Aside from that, I think the previous witness gave eloquent testimony to something that I firmly believe in, and that is that major efforts of this type which involve in this case, as it does in international effort, signal to me a statement of hope for the future, not just something that can be done exciting in science.

It says that where we, as a nation, believe in ourselves, we believe in our future, and we are willing to invest in that future. This is part of a statement that says that we have that future.

Where that space station will evolve is a very open issue. This was certainly no more than a first step, I think. The way in which it will evolve, I believe, we need to get the experience to help guide us in terms of making that decision.

As you are aware there are groups, and I am a member of the academy's long-range study group looking at space science 1995 to 2015. There are some very ambitious science plans which are being envisioned which go far beyond the space station that use the space station as a jumping off point.

Senator **Riegle**. Give us a couple of illustrations of that.

Dr. **Black**. One is in the area of planetary research. That would be the ability to assemble at the space station a new generation of planetary spacecraft. We right now have to assemble under a very miniaturized extreme to survive the launch capability. The potential is there for building somewhat flimsier structures and using the capability of man on orbit to do assembling of spacecraft and send him out from the space station.

In the area of astronomy and astrophysics, there are currently being envisioned a large number of exciting telescopes which would be, again, assembled to use the man capability to assemble structures on orbit, the large deployable reflector, an infrared 70-millimeter device, being one of those.

So these are areas in terms of those disciplines where they are looking at some very exciting science capability in the future.

Senator **Riegle**. Dr. Hudson, what would you have to say?

Dr. **Hudson**. I would like to thank you for the question, because I ask myself sometimes why I am so interested in the space station. I think the main thing that I see is that one has to put in balance the development of infrastructure, I guess, in space with the use that you put that infrastructure to. That is the best way to start the comment.

In a sense, the infrastructure has to lead the applications to a certain extent. In this country, I think it is a sharp contrast to the Russian program. In most fields that I am directly familiar with, we have had a very healthy balance between use and infrastructure development.

In fact, we have a great lead over the Russians in these areas, but as I say I think it is necessary to push the infrastructures beyond what the users know that they really want to use in a reasonable way.

In the space station, what one is really doing, I think, is adding new disciplines of research and application to what we are able to do now. These new disciplines deal with the use of the low gravity that is there.

Of course one can only speculate but it would be quite surprising to me if something like analogous to the discovery of the Van Allen radiation, for example, did not take place through the acquisition of these new facilities. I mean, Van Allen was able to do his experiments because people beforehand had invented the rocket, not intending to discover the Van Allen Belts. There is sort of a joke in the space plasma physics business that they should have been called the Vernoff Belts after the Russian space scientist who could have had an experiment on a Russian vehicle earlier than Van Allen did.

So that is one aspect of it, and then the other is in our field, in the fields that we already know something about, research and space. For instance, in astrophysics, just looking at this you can imagine having the astronauts actually create large structures to do new and important things.

I think we ought to recognize that many of the experiments that we are doing in space now that we want to do are just too expensive. Part of the reason is because they are big, but part of the reason is because they have to be put together and made to work automatically and deploy automatically under very severe conditions and be perfectly reliable.

I think with the repair by the astronauts of the solar maximum mission and that sort of thing, one is seeing the first halting steps toward a real capability to do work in orbit that can replace some of the work that is done on the ground. For example, attached to this space station are not just big platforms but also small free-flying satellites which can usually be made to dock and be serviced and repaired by the astronauts.

To change instruments, an instrument can be built on the ground without a satellite and be launched in a suitcase, and the astronauts can take it out and put it into the interface, and it can fly away and do its research.

Not just in astrophysics but also in microgravity, because there is no question that no matter how competent the design of the space station is, there will be effective gravity levels that are too high for some kinds of microgravity research.

So there will be a swarm of little platforms and satellites flying around the structure, and they will be administered and tended and serviced by the astronauts. I think that is something that we will not really understand how to use until we have had some experience, but it is bound to be revolutionary.

Dr. **Black**. Senator, may I just add one point? We focused on the space station, and rightly so. That is the topic of the testimony, but I think all of us in the community feel that it is equally important to maintain a sense of balance in the program between those scientific activities and endeavors which use the space station and those which do not.

There is a great deal of truly exciting science that is not space station related, and I think it is fair to say that none of us would like to see the funding for that jeopardized at the expense of doing this science on the space station.

Senator **Riegle**. Dr. Hudson, you may know this and you may not, and so I want to pose it as a question.

Are you aware of the fact today that the Air Force Space Program is twice as big as the NASA Space Program?

Dr. **Hudson**. Do you refer to the Black Program or the Blue Program?

Senator **Riegle**. So you are generally aware of the fact that we have seen that kind of, I think, explosive growth in the Defense Base Program, and we have seen something quite different on the NASA side.

I think it has been squeezed down, if you will, by a number of measures, and I must say, as I try to balance as a Senator all of our competing requirements, defense requirements and scientific research requirements which I hold to be quite important myself, and there are commercial requirements in terms of using space, I am beginning to think that we may be getting lopsided in the sense that star wars obviously has had a lot to do this.

SDI is a thing that eats an awful lot of dollars, and I think what can happen is that traditional space programs, the Balanced Space Program as we have thought about it over the years, of exploration and research and development and pioneering new applications and stretching the frontiers and so forth.

I am concerned that it is shrinking as a percentage of the whole. It is not exactly the tail on the dog but it looks to me like it is moving that way. It is becoming the tail on the dog, and the dog is increasingly the defense side of the space effort.

I am uneasy about that. I am uneasy about it for a lot of reasons, including the question of whether anybody gains if we go out and militarize space, particularly if we could work out some agreement to prevent that so that nobody has to spend the money and divert the resources and so forth so that in turn we can concentrate on a different kind of mix of activities and we can go out and make these discoveries and advance the science and figure out how to improve the quality of life for ourselves and people around the world.

It seems to me that there are enormous opportunities. It has not been that long in human history since we found the industrial revolution aspects of sort of improving the way we do things and the quality of life.

Now we are at a point where there is an opportunity, I think, for a succession of miraculous breakthroughs if we can just supply ourselves sufficiently with good scientific work to find new things, new answers and then figure out what to make of them and how to bring them back in ways that really make life different and better for people.

Yet, I feel as I have served here in the Congress now for 20 years that those are tending to get deemphasized despite the fact that the two of you are hard at work at it. I get the feeling that those areas are fighting harder and harder to get less and less, whereas other areas are coming along and are really the ones that are serving and growing.

I do not know how we answer that right now, because that in a sense is the product of a lot of complicated national decisions where in the end the public needs to speak as to what they think is the right balance, but they speak through us.

It is hard for the public to understand what the choices are, and that is one of the reasons I posed the question as I did. I think it is important that we try to put in plain language what our choices what, what is at stake here, what we can hope to accomplish if we do this, if we spend the money, what is there in the way of a benefit that is going to accrue to people that they will see in the lifetimes of themselves and their families.

I think that is how we maintain the commitment. That is how we get the resources and how we stay on track doing these things. I think we have to do a better job in that area. I think that we are all spread thin because there are a lot of things to keep track of; terrorists in Libya and the farm problem and trade deficits and physical deficits and what happened to the *Challenger* and a whole host of things.

In the midst of it all, I think there is a new burden on us and on you to figure out how to really make clear what these choices are so that the public can take hold of that information in a way that is relevant to them and become part of that decision so that we can really get some national decisionmaking, we can really get some national feeling of public will to want to do certain things.

So I guess what I am saying is I am going to work harder myself to try to figure out how to put this in terms so that these choices are clear because we cannot do everything. I mean, we have run out of money. We have got deficits of $200 billion. We are now under the Gramm-Rudman discipline which cranks down our spending, so we are going to have to spend less for a lot of things.

It may be that the NASA should not be half a large as the defense base budget. Maybe it should be bigger than that. Maybe the defense base budget should not be growing as fast as it is. These are questions that scientific people like you are going to have to get right in the middle of.

I do not think you can just walk up to the line of the scientific questions and then stop short and not get embroiled in the tradeoff issues and national priorities. I think you have got to come on over the line with the rest of us and try to be part of the debate as to what it is we are going to do and what it is we are not going to do, because we cannot do everything.

I think the more we can make it plain and understandable, the better informed the public will be and in a position to make these judgments and to speak and come back in on the Congress. We can decide where we want to go.

I think there is a lot of risk right now as to whether we are going to stay on track with the kind of important scientific and research work in space. It seems to me to make sense to do that. I think there is some real jeopardy as to whether or not we are going to get the funding on an adequate and sustained basis to stay on that track.

If that is so, I think it is going to take more work to do it, and it is going to take more work to convince people that that makes sense and be more specific as to why it makes sense and use historical analogies and various other things to try to build that kind of base of support.

We are a pioneering people, and I think you know we are a people that apparently seek that next frontier and I suspect always will. I see some real budget and policy problems here that are of quite major dimensions, so I think fostering this debate in these kinds of terms that I am trying describe here I think is an important part of accomplishing what you want to accomplish.

So with that, let me thank you for coming today.

The subcommittee will stand adjourned, and we will reconvene at 2 p.m. for the nomination hearing on Dr. Fletcher.

[Whereupon, at 12:15 p.m., the meeting adjourned.]

NASA AUTHORIZATION

THURSDAY, MAY 8, 1986

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE,
Washington, DC.

The subcommittee met, pursuant to notice, at 9:40 a.m., in room SR-253, Russell Senate Office Building, Hon. Slade Gorton (chairman of the subcommittee) presiding.

OPENING STATEMENT BY SENATOR GORTON

Senator GORTON. Welcome to this hearing of the Subcommittee on Science, Technology, and Space as it continues its consideration of NASA's fiscal year 1987 authorization.

Today's review will focus on the authorization of NASA's space transportation system and related space transportation safety issues. Our Nation's ability to enter space has been reduced to a level which 4 months ago would have been considered unthinkable. The accident of the Delta ELV is all the more shocking given the successful history of this vehicle, 43 consecutive successful launches since 1977.

We have cause for further concern in that the Delta rocket carried a NOAA weather satellite known as GOES which would have generated critical weather information. The loss of this satellite leaves us with just one healthy GOES satellite in orbit and one more to be launched in this decade.

This morning we will discuss the potential effect of this accident on NOAA's weather forecasting capabilities and the future of the GOES system. This accident of the Delta in combination with the *Challenger* tragedy and the Titan accident has created an unprecedented level of uncertainty in our space program. Before the Titan and Delta accidents, there was a general tendency to feel some measure of comfort in our remaining ELV capability. That comfort no longer exists, and we are reminded once again of the risks and dangers of space flight.

Notwithstanding the coincidental nature of these three accidents occurring within a relatively short period of time, we are nevertheless forced seriously to examine the state of our Nation's space transportation capability. Furthermore, given the dangers and risks that still exist in unmanned space flight, one may be forced to reconsider the privatization or commercialization of these launch systems.

Since the accident of the *Challenger*, the subcommittee has held several hearings in which the capability of a three-orbiter or four-orbiter fleet has been discussed. The preponderance of the testimony has clearly indicated that a three-orbiter fleet, even if operated in combination with an expanded ELV capability will not adequately serve our nation's various civil and military launch requirements, yet Congress continues to wait for the senior interagency group on space and the President to send the appropriate signal to initiate the replacement of the *Challenger.*

As regrettable as Saturday's Delta accident was, I hope that it forces the Senior Interagency Group on Space to expedite the completion of its work so that we can go about the business of restoring our space launch capability. In fact, I must add to this statement that the failure of the interagency group to come up with a recommendation is at this point, as far as I am concerned, inexcusable.

This subcommittee and its parent committee are simply going to have to go ahead and set these priorities without recommendations from the President if it does not get off its duff and get to work. Even with the Titan and Delta accidents, we cannot overlook the role the ELV's, whether of a public or private nature, can play in the future. It is clear that some national ELV capability will be an important factor in our Nation's space transportation system, and it is not too soon to begin the process of determining the nature of this capability.

Another transportation issue which warrants consideration is that of upper stages, and more specifically the Centaur upper stage program. Over the past 2 years, this program has been fraught with cost overruns and technical problems. Now concerns related to its use on a manned vehicle in combination with a plutonium fuel source are heightened. Congress and NASA have already made a significant investment in this program, and now circumstances dictate that we examine this investment and the program itself in the context of these new concerns.

While this hearing does not purport to investigate the accident of the *Challenger,* it will nevertheless examine the issue of shuttle safety, particularly in the context of the findings and recommendations of NASA's aerospace safety advisory panel. Shuttle safety cannot be taken for granted any more, and now more than ever the subcommittee must maintain a constant and probing level of oversight into the issue of shuttle safety.

With these thoughts in mind, we are delighted today to have Admiral Richard Truly, NASA's Associate Administrator of Space Flight, and members of NASA's aerospace safety advisory panel, all of whom should contribute significantly to the discussion of the issues before the committee. We also welcome Tony Calio, the Administrator of NOAA, who will discuss the implications of NOAA's having lost a critical satellite in last Saturday's Delta accident.

Dr. Calio will discuss the status of the GOES system and any measures NOAA or the Congress can take to ensure system continuity through the next few years. Dr. Calio was here just 3 weeks ago to discuss the NOAA satellite budget, but the loss of GOES-G causes us to call upon him once again, and we appreciate his appearing on such short notice. Senator Riegle.

OPENING STATEMENT BY SENATOR RIEGLE

Senator RIEGLE. Thank you, Mr. Chairman. Let me begin by associating myself with your remarks. I think your statement of concern about the slowness of the top policy body for space strategy and activity has been very slow to act, I think is correct, and it is a sorry fact, and we are way behind. Obviously, we have had extraordinary disruptions because of the succession of accidents, topped, of course, by the *Challenger* disaster, but there really is no acceptable reason why this group is not able to move faster and to provide some kind of clear policy direction.

I think what has happened is that we are caught in the kind of classic bureaucratic tangle that ends up when you have got too many people with differing agendas trying to deal with a complex problem where they have got other things also that have a very high priority, and the job just does not get done.

I suggested the other day that I think it is time for us to reestablish something like the National Space Council that we had years ago with presumably the Vice President in charge of that. That worked well in a previous time when we needed to expedite our policy decisionmaking, and I think clearly there is a need for something like that, perhaps that same structure now, in order to expedite a policy decisionmaking at this time and particularly at this time. I think the challenge that we face now in terms of getting the space program back on track, in setting a solid and realizable goal structure for the future and being able to give clear signals out to the country and to the private sector is just essential.

I think our national security interests are very deeply involved in these decisions, and yet I detect that at the very highest level we are drifting, that the attention is going to other issues, and basically space policy decisions which urgently need to be made are not being made, and there really is no excuse for it, and I think the chairman has stated it very accurately. Presumably at the operational level within NASA, with the confirmation of Dr. Fletcher, we will be in a position now to deal with some of the internal difficulties and some of the management drift that I think we have seen over some long period of time.

This does not reflect on you, Admiral Truly, because you are relatively new to your assignment, but it is clear, I think, to all of us that there is a need for a strong, centralized operational control within NASA, and many of us are of the view that Dr. Fletcher will provide that, and now can do so immediately, having been confirmed, and due to be sworn in to the office very shortly.

I want to say with respect I have a statement, Mr. Chairman, I would like to read for the record.

Senator GORTON. Without objection.

Senator RIEGLE. Mr. Chairman, members of the committee, today we are holding what may be our final session to develop the fiscal year 1987 NASA authorization, and we will hear testimony on the current status of the Space Shuttle Program and the Space Transportation Program in general.

Clearly the Space Shuttle Program was the most directly affected by the *Challenger* tragedy. A program that had been operating with an increasing degree of confidence was shattered on the morning of January 28, and one of the primary tasks that Admiral Truly faced when he took over the program was the restoration of that confidence.

We want to help Admiral Truly put the Shuttle Program and indeed the entire space transportation system back on track. We have seen in the course of these hearings that our capabilities to put satellites in space, whether with the shuttle or with ELV's are strained. And with the Delta loss last weekend, our entire Space Transportation Program is effectively shut down, a position that we have not been in for almost 30 years.

So, there is something very young, and we the Congress must work with NASA to find and correct the problems. It was a partnership between the Congress and NASA which put men on the Moon and built this program, it will have to be that same arrangement which brings the program back to preeminence in the world. But this cannot be done without complete honesty and openness on both sides.

I am troubled by the testimony that we will receive today since it strains credibility. NASA is projecting flight rates with a three-orbiter fleet that are greater than those ever possible with the four-orbiter fleet. A resumption of flights is predicted for February 1987, based upon the NASA planning baseline. Much as I would like to believe that, looking at all of the evidence on the cause of the booster rocket problem, and the difficulty in engineering a fix, I must say that February is terribly optimistic. Even press sources refuse to grant credibility to that prediction. If it's going to be 18 months minimum, NASA should simply say 18 months.

Mr. Chairman, perhaps the most troubling aspect of the testimony today, is the lack of budget information that we, as the Congress, can rely upon. We all know that it will take a large amount of money to restore the program to the previous capacity. We all know that fixing the shuttle will cost a lot, as will the purchase of ELV's to complement the system. We all know that the *Challenger* loss must have cost NASA money in many ways—in storage of satellites, continued operation of ground stations, the search operations, whatever. Common sense tells us those things, and before we can get on with the task of repairing the system, we need to know precise estimates of the costs associated with all aspects of the program. And yet, none of those numbers are available from NASA over 3 months after the accident.

So, Mr. Chairman, I want to be certain that before we take final action on a NASA authorization bill, that we know exactly what the program needs are, what the money will be spent for, and how NASA expects to put the program back into operation. The time for unfounded optimism has passed, and we must make some hard choices now, to produce results 3 years from now, be it more ELV's or two more orbiters. And the only way that we can make those hard choices is with a full knowledge of all of the facts, pleasant or not, about where the program stands, and what it will take to restore it. That is why, Mr. Chairman, we will need at least one more session to review the final NASA fiscal year 1987 budget request, as well as to consider any fiscal year 1986 supplemental requests.

I would just touch on a couple of other points within it. I am troubled about the fact that we are not getting in my view serious or relevant or meaningful budget estimates in terms of what needs to be done and guidance as to how we might do it. I realize we are still in the aftermath of the accident, and we are trying to reconstruct what happened then, so there are a series of efforts going on to decide what equipment problems there were and systems problems and decisionmaking problems and things of that sort, and a lot of people are out doing those tasks, but I must say 3 months down the track here that the absence of meaningful and relevant budget information is really just inexcusable, and I do not quite know why that is so. The only thing we have really gotten was sort of a very rough estimate informally several weeks ago that looked as if there would not be really any net cost impact on the NASA budget from the *Challenger* accident. The perfect offset between cost associated with the accident and then certain reductions presumably that the program could make that would equal dollar for dollar those premium costs.

That is just not believable, and I do not know whether OMB is the force that is causing NASA either to remain deliberately vague on budget requirements or it comes from some other direction or some combination of directions, but we have got to get accurate planning estimates here that are not overly optimistic, and we have got to get tangible budget projections that we can have some confidence in.

Confidence has been shaken in NASA in a whole host of areas because of the succession of accidents and so forth, and we certainly should not add to that by there being a lack of confidence in what the budget projections are. Somebody in NASA is going to have to be willing to speak out, and if the pressure from OMB or some other source is to take and to fuzz this off, and to keep it vague, and so that we cannot understand what the true facts are, somebody is going to have to be strong enough and steady enough to tell us what the truth is, and not in a whispered conversation in a hallway, but in open public session like this. So we need some good, solid budget projections. We do not have them, unless you are going to bring something today in addition to what is in your printed statement which, as I review it, really does not contain the information that we need to have.

I am also concerned about the projections on planned flight rates. As things stand now, you are projecting flight rates with a three-orbiter fleet that are greater than those that were ever achieved with a four-orbiter fleet. I just question right on its face whether that is realistic. I think the resumption of flights being predicted for February 1987 based upon your planning baseline, I think, looks to me to be really unrealistic, and I do not know why we would be erring on the side of floating numbers that probably cannot be met in terms of a timeframe for when we are able to fly again.

It just seems to me that is terribly optimistic, and I must say that I am not able to put together any body of information that I have confidence in that would lead me to think that that is the case. It looks to me as if it is going to be longer than that, and so rather than set expectations that are either unrealizable or perhaps just not credible, I think we would do much better to be very tough in our judgments as to when we are going to be able to function here again.

I have to believe there were some very substantial extraordinary costs associated with the disasters that we have had, not just in the loss of equipment but in all of the ancillary expenses that one can just know from common sense have taken place, storage of other satellites that we were planning to send up, operations of ground stations, search operations. There have to be a whole host of things here, and yet we do not have any meaningful summary of the numbers here so that we can crank it in to try to decide what we ought to go and ask for from our colleagues in the Senate in the way of the budget totals that we need for the future here.

So somebody has got to get on this financial problem, and if you do not have the people that you need to do that, or if the overall command is fractured in some way, then you had better find somebody, because good financial people can be found, and then we are going to have to be realistic in terms of the assessments that are made.

Now, I would just say in conclusion this. I am prepared to work hard to help NASA achieve the level of funding that it needs to get back on track here. I think it is essential that it get back on track and get back on track quickly. I think that this shutdown period is very damaging to our country.

I think the fact that we are falling behind on the space station——

The Russians are up there with their space station. At the earliest we are anticipating an operational U.S. space station 8 years from now, where the Russians are up there today with theirs doing important experiments that will benefit their society. We need to be closing that gap, so we have got to get back in the air, and we have got to get back in the air on a basis that we can afford and where we maximize the safety factors. There are many of us here who want to help you accomplish that, and we will help you accomplish that, but you have got to give us something to work with here in terms of solid, credible estimates, in terms of both solving equipment problems and flight problems and also wrestling these numbers into place, the financial side of this puzzle.

We have got two space programs today. The defense program in space is twice as big as NASA's program, $15 billion in the defense area to roughly $7 billion in the NASA area. I am concerned about that. In fact, I am not even convinced we ought to have two separate space programs, and that is another issue we are going to have to get into. But I can tell you this. NASA is not going to be able to hold its own here if you are not able to come in here with tough, hard, credible budget numbers and flight projections that we can hang our hat on. If you can give us those, we are going to be able to do a lot more to be helpful in terms of persuading the Congress to move and to enlist the broad public support that is necessary to get through this very, very difficult period. I know a lot of people in NASA are working very hard, and my hat is off to them. It is a very difficult time, and we are here to try to help, but you have got to give us more than you have given us today in these initial submissions for us to be able to help get this job done.

Senator GORTON. Senator Trible.

Senator TRIBLE. Mr. Chairman, you will be pleased to know that I have no long opening statement, but rather I welcome the witnesses, and I do look forward to hearing their testimony at some point.

Senator GORTON. Senator Gore.

OPENING STATEMENT BY SENATOR GORE

Senator GORE. Thank you, Mr. Chairman.

I want to associate myself with your remarks, and with those of Senator Riegle. All of us here are very concerned about the plight of our space program. NASA, which has been a source of so much pride and inspiration for so long, has stumbled badly in the past 4 months. After 30 years of steady success, our future in space flight has now been placed in doubt.

Mr. Chairman, NASA's image changed over a period of a few weeks, but I believe it is now clear that the substantive change in NASA took place over a period of many years. After the magnificent triumphs of the Mercury, Gemini, and most of all the Apollo programs, NASA began to drift, to lose its sharp focus and its fine edge of excellence.

This morning in my questions for Admiral Truly I want to explore one particular aspect of this change that is particularly disturbing to me, and I speak of the dismantling of NASA's quality control capability. In the wake of the shuttle explosion and the failure of two ELV systems, some have said that NASA is simply having an extraordinary run of bad luck. I wish I could believe that explanation.

It is far too early to pinpoint the cause of these failures, but I believe the evidence is now beginning to point overwhelmingly toward a serious breakdown in quality assurance. At this point, Mr. Chairman, I would like to ask unanimous consent to introduce into the record documents showing that over the past 15 years since Apollo landed on the moon, NASA's quality assurance program has not only been eroded, but in some cases it has virtually disappeared.

I have provided for Admiral Truly some charts which I wish you would focus his attention on at this time. The first chart illustrates what has happened to the number of quality control or quality assurance personnel at the Marshall Space Center over the past 15 years. As you can see, it has been cut by about 86 percent, from 615 people in June 1970 to just 88 people this past year. At Kennedy Space Center quality assurance has been cut by more than half, from 326 to 145.

At Goddard, Ames, and Langley, it has been cut by two-thirds. At the Johnson Space Center, the number has been cut from 248 to 79, a cut of more than two-thirds. Overall, the number of people assigned to quality control and reliability assurance has dropped, has been decreased by 71 percent since the Apollo landing on the Moon. I have tried to get figures exactly like these for quite some time, and only in the last 2 days—well, before I was told they did not exist, but 2 days ago I located them inside NASA. NASA itself verifies the reliability of these figures showing that in all the centers quality control has been cut by far more than half, an average of 71 percent. The only exception was Lewis, where the number was low to begin with.

Mr. Chairman, in my view these numbers reflect a devastating decay of what was once the finest quality control program anywhere. I would like to have some explanations for this cut. NASA may try to tell us that it has fewer inspectors because contractors are picking up the slack. I do not think that explanation would make any of us sleep easier. Considering our experience in other areas of procurement, we know we cannot rely on the objectivity of contractors to guarantee their own products.

NASA may also try to say that the numbers do not include civil servants elsewhere in NASA who now do the work of quality control specialists, but reassigning that critical responsibility to someone who already has a full plate is no substitute for having inspectors whose duty is quality control and nothing else.

It may be, Mr. Chairman, that after the stunning and dramatic success of the Moon landing, NASA became too willing to trust in technology without the kind of thorough checks which accompanied the Apollo program. There were so many successes to rely on that it may have given the agency a kind of technological hubris, a kind of illusion of invincibility. Under budgetary pressures, the choice was made that the program might get by without the same standards of excellence insisted upon in the past.

As I say, it is too early to say with certainty that there is in fact a common denominator between the recent failures, but it may well turn out to be these chickens coming home to roost. Quality control is not an activity with a lot of sex appeal. It does not translate into public relations, but it is absolutely essential.

In my questions, I hope to explore this, and in the longer term I hope to convince you, Admiral Truly, and the other new leaders at NASA to turn your attention first to this aspect of the program as the first step in rebuilding the NASA we once knew.

Thank you, Mr. Chairman.

Senator GORTON. Senator Ford.

Senator FORD. Thank you, Mr. Chairman.

I am not a member of this subcommittee. I formerly was a member, and have a great interest in this program and what is going on, and I appreciate the opportunity afforded me to sit with you this morning and listen to the testimony.

Senator GORTON. We are delighted to have you.

Admiral Truly, we would be happy to hear from you now.

STATEMENT OF REAR ADM. RICHARD H. TRULY, ASSOCIATE ADMINISTRATOR FOR SPACE FLIGHT, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, ACCOMPANIED BY JOSEPH B. MAHON, STS SUPPORT PROGRAMS DIVISION; AND MACK STEEL, RESOURCES AND INSTITUTIONS DIVISION

Admiral TRULY. Thank you, Mr. Chairman. I am pleased to be here to testify this morning. With your permission, I would like to submit my testimony for the record and make a few initial comments.

Senator GORTON. Your written testimony will be included in the record.

Admiral TRULY. Thank you, sir.

Since I arrived back to NASA about a month after the *Challenger* accident my major effort has continued to primarily focus on that accident, to support Chairman Rogers and the Presidential commission as they investigate the accident in my role as chairman of the NASA task force, to support them in their investigation, and I think that is going very well, and I think they will report out to the President on schedule, and we are doing everything we can to support them in every way.

The next thing that I turn my attention to, which is also part of the public record, was to try to galvanize the Office of Space Flight, our centers, our people in a strategy to safely return the space shuttle to flight, and this strategy I directed into the system, and it includes a number of things, an entire program management and organizational review and, I might add, a review of the quality of our quality assurance program that Senator Gore mentioned fits very nicely into that.

We have started a major effort in the redesign of the field joints and of the nozzle joints and a relook at all potential leak paths in the solid rocket motor, and a major design team that includes not only NASA personnel from a number of centers, but also other outside people. We intend to appoint an independent oversight group reporting to NASA Headquarters to stay with us throughout this design and through the certification and test program until we are back in flight.

We are looking again into the design requirements of the shuttle. We are reviewing every last critical item in the shuttle system, not just in the solid rocket motor but in the orbiter and external tank, and our procedures. I have given directions so that the program can plan a first flight and the first year of operations, and we have also set into motion a major effort to determine a safe, sustainable flight rate, which Senator Riegle quite rightly noted, and I am prepared to talk to that.

During this period, the Air Force suffered a Titan 34D loss out at Vandenberg. We have NASA people that are supporting them just as the Air Force is supporting us in our *Challenger* investigation. I do not have any results from that investigation, but I can assure you that when the Titan 34D investigation is complete, we will take it into account with the same rigor with regard to our system if there are similarities, and there very well may be.

I think we have made major progress. In the latter part of last week I came with an interim report to the Acting Administrator, Dr. Graham, on the results and the status of this program review, looking to the future, not to the past, and talked to him about the general area of when I thought the first flight could be and what I thought the rates could be, and then we suffered another major setback in the loss of the Delta Saturday evening at the cape.

That accident at the moment, it appears, was caused by engine shutdown at about 70 seconds into the flight. Up until a couple of seconds before the accident there was no indication of any anomaly. Incidentally, I might add that we spent major efforts preflight in major reviews of that system. A couple of seconds before the engine shutdown we saw indications of a major electrical short in the system. We saw two very limited duration shorts, and about a second later the engine shut down and the vehicle lost control, and we lost the Delta and the GOES satellite that was aboard.

We got an accident team in place, that was at work on Sunday, at least, with the chairman there at the Kennedy Space Center. We are presently analyzing and beginning to do testing and trying to understand the accident since we had underwater search equipment and ships on the scene at the cape. On Monday afternoon or Tuesday, after talking to the accident board, I authorized that we send some of our capability to the area to try to retrieve the boat tail and the engine section of that vehicle.

We have had three hard contacts by sonar. The engines appear to be, and we have a visual video citing of what we think is the boat tail. It is in about 420 feet of water, and appears to be severed just above the thrust structure. We intend to attach floating devices to it and bring it to the surface if we possibly can. I hope to be able to report in the next few days that we have done that. I think it will help us in our investigation if the weather is good.

Yesterday, after discussions both within NASA, and with the Air Force, and with the Navy, we delayed the next launch of the Atlas Centaur which was scheduled for May 22 for a period of about 4 weeks which will allow us to cause a thorough review of the pedigree of that system. The engine on the Atlas Centaur is not identical to the engine on the Delta. However, it is of the same family, and we want to do the most prudent things that we can to make sure that we are ready to fly on the set launch date.

The payload on that satellite is a Navy fleet satellite communications vehicle. Yesterday, I started a major internal review of the shuttle Centaur so that we, as you already know, have a number of reviews, an independent safety review that is going to be conducted on the Centaur vehicle but that will take a number of months. I have asked our shuttle level 2 organization and the centers involved and the program office at the Lewis Research Center to support a review in the next several weeks to report the status of the Centaur program to me so that I can report it to Dr. Fletcher, the Administrator of NASA, and we can reassure ourselves and the Congress and reassess that program to assure that we choose the proper course for that crucial undertaking.

In summary, we are taking action across the board as fast as we can and developing the underpinnings of the kinds of information that will allow us to move forward both in a programmatic sense and a budgetary sense. Dr. Fletcher has been confirmed, and I look forward to him being sworn in and on board so that he can deal with those major policy and program issues that have to be dealt with at the agency level as we strive to get our Nation's space program back on track.

I have invited this morning with me two witnesses to help answer your questions. On my right is Mr. Mack Steel, who is head of our Resources and Institutions Division, and on my left is Joe Mahon, who is head of our division that is in charge of our ELV boosters. That concludes my remarks, sir, and I would be pleased to try to answer your questions.

Senator GORTON. Thank you.

There will be a large number of questions, and so in order to see to it that everyone who is up here at the head table, including Senator Ford, has an opportunity, I will limit the first round, at least, to 10 minutes each, including myself, and then we can go back through a second time. Admiral Truly, with respect—excuse me. Senator Hollings, do you have an opening statement?

Senator HOLLINGS. No. Thank you, Mr. Chairman. I appreciate it.

Senator GORTON. With respect to the Delta accident, do you have any information at this point that would indicate that either this is a generic problem or a problem unique to this particular engine?

Admiral TRULY. No, sir, we do not. We do not understand specifically what the cause of the shutdown was. We are confident that there was an electrical short somewhere in the system, but we have not had the time to isolate it.

Senator GORTON. How much do you think it is going to cost to investigate the accident, and are you going to want to replace the Delta?

Admiral TRULY. I do not have an estimate today as to the cost to investigate this accident. The salvage operations that I mentioned frankly will not be a large expense because the capability was already in place. I think that hopefully we can get this investigation done in less than the time that I have allotted the board, which was 60 days from the accident. I will be glad when I can get an estimate to provide it to you.

Senator GORTON. We would like to have that. Now, you have already spoken to the postponement of what was scheduled as the Atlas Centaur launch on May 22. How will the Delta accident in your view affect Delta launches which are now scheduled for August and October?

Admiral TRULY. I am afraid that we are going to have to understand the cause of this accident. My guess is that when we do, it undoubtedly will require a thorough inspection of those vehicles. When we understand the actual cause, there may be some redesign that is required, but it is just too early to tell.

Mr. MAHON. I think that is a fair statement. These vehicles have been built and are stored and are ready for launch at that point in time. Since we do not understand what the impact of the failure is on those vehicles, we are planning to proceed with the launch, but we would be ready to adapt anything that is necessary to change to prevent a reoccurrence of the accident.

Senator GORTON. As you know, Admiral Truly, in the aftermath of the *Challenger* accident, there has been a great deal of talk about a more balanced launch capability, including both the shuttle and ELV's. Have the two most recent ELV accidents altered your thoughts on ELV's and their role in our Nation's launch capacity in any respect at all, and for that matter the question of privatization of ELV systems?

Admiral TRULY. No, sir. As incredible as it seems, I have no indication today that these are not three totally coincidental accidents that have no direct connection that I can find, and in answer to your question, in my personal opinion it does not change my personal view for the need for this Nation to have a balanced ELV and space shuttle capability.

Senator GORTON. On another subject, your prepared testimony, your written testimony indicates your view that a three-orbiter fleet could sustain a flight rate of 12 to 18 launches a year. Senator Riegle expressed grave reservations about these estimates. The projections with a four-orbiter fleet were certainly much greater before the *Challenger* accident, and I must associate myself with his serious reservations in that respect. Can you tell me, is that just simply a goal which you might have if everything went perfectly, or is it something on which you can express a realistic view of attainment in the first year or two after we begin launching orbiters?

Admiral TRULY. Yes, sir. I would like to comment on that if I could. In order to get going again, what I directed be done in order to try to determine the safe and sustainable flight rate for the shuttle system was to have our system go back to our capability, not only our orbiter processing capability and the hardware that we have at the cape, but also the people that we have work shifting at the cape, mission planning activities in Houston, crew training, and try to form my own opinions based on these various recommendations as to what a safe and sustainable flight rate would be.

Early on, as you know, and prior to my coming, there were two manifests that were a 12-month down manifest and an 18-month down manifest that were set in place. They were done without a detailed assessment of the *Challenger* accident or a detailed assessment of what our flight rate might be, and I pledged myself to try to make my own recommendation as to about the time that I thought the first flight could be and what the flight rates could be.

I have done that internally, or at least I have taken what I would call a midcourse assessment of where the people are because frankly this is a huge job, and it is being done at all of our centers. So the 12 to 18 numbers were essentially, the number, at least, was based on those early budgetary planning estimates. I have gone back and looked at our actual turnaround times, and it appears to me that in our recovery period and what I have recommended and in some detail to the Acting Administrator and have discussed only briefly with Dr. Fletcher is a buildup rate of about 6 to 7 flights in the first year, 9 to 11 flights in the second 12 months of operation, and I am sure that we can sustain a 12 to 13 flight rate with 3 orbiters. I believe that depending on the payloads that are manifested, and I would like to speak to that, that the system should be able to sustain a goal of about 15 flights per year or about 5 per orbiter.

This is a complicated subject, in my view, because some of the payloads that we have to process take longer than others. For example, a pair of simple commercial satellites can be processed, and if you had 15 of those manifested per year, I believe the system could grow to a capability to meet that.

Senator GORTON. That sounds to me more realistic. I think still perhaps hopeful but more realistic. At that rate would you work off the backlog of payloads at all?

Admiral TRULY. Yes, sir. We would, although it will take longer than the higher projected figures. What I have tried to do is be as realistic as I can in my recommendations with keeping safety in mind after the accident. I must point out, however, that there are some that disagree with me, and this assessment is being assessed now within NASA's senior management, but I think those types of numbers are achievable.

Senator GORTON. Before the *Challenger* accident, NOAA had agreed to launch GOES-K, L, and M on the shuttle rather than on refurbished Titans beginning in 1991. Is that still a valid decision, or should it be reviewed?

Admiral TRULY. Mr. Mahon will address that.

Mr. MAHON. The option to launch those vehicles is still an open question. NOAA has indicated that they would like to launch them on expendable launch vehicles, and the agency has indicated that they would prefer the shuttle used. We have installed the space shuttle at the Vandenburg Air Force Base site, and it would be a good use for that system, and so the question is still open for discussion at this point.

Senator GORTON. Admiral Truly, on another but related subject, the April 24 New York Times article on NASA safety measures leaves the impression that during the development of the shuttle NASA eliminated or deferred a significant number of tests, the criticality of which is not specified in that story. While this article referred to a period of time that certainly precedes your responsibilities, what are you doing now, particularly in your review of all shuttle and criticality 1 items, to assure a comprehensive testing of critical shuttle systems?

Admiral TRULY. During the down time, the first thing that we are doing is for each criticality 1 or 1R item, we have essentially canceled the certification of each of those items and are requiring each item to go back through a complete recertification process, and the purpose of this is to make sure that we do not have other single items in the system that are critical to prevent the loss of a vehicle or crew that require hardware change prior to the next flight. That work is in process.

My assessment of it is that there will be a very limited number of items that we will have to make a design change to, but that process, and we are trying to, since several of them are already being discussed actively in the system at the time of the *Challenger* accident, we are looking at those first to see if we can make an early decision if we have to to protect the schedule to get back to flight, so there is a schedule risks, but not a safety risk in my approach, I think.

The total review, however, will take most of this year. There are a lot of items, and we are going to go back through every last one of them.

Senator GORTON. Senator Riegle.

Senator RIEGLE. Thank you, Mr. Chairman.

We could probably go through important questions all day here, and so I am going to touch in a number of areas, and then depending upon the time we have, go further in several of the areas. On March 10 this subcommittee was provided an official sheet by NASA that depicted the 1987 budget impact of the shuttle disaster, and I made a reference to that in my opening comments, and basically that sheet estimated that the accident impact was going to be an additional cost of $497 million, and then you found other areas in which to make savings of precisely the same amount so that the net effect of the accident from a budget point of view would be zero because of the offsets that you would find.

Are you familiar with that estimate?

Admiral TRULY. I am not familiar with that particular estimate, but I think Mr. Steel might be able to comment on it. I am not personally familiar with it, sir.

Senator RIEGLE. Are you familiar with it?

Mr. STEEL. I believe so, Senator Riegle. It represented a summary of fiscal year 1987. It was done similar to the revised operating plan that the Agency submitted in late March for fiscal year 1986. The approach, as I understand it, was done from a total agency standpoint. It identified the reductions that would be able to be accomplished as a result of the standdown in the flights.

It then looked at, with the flexibility that you developed as a result of those, I will call them savings or reductions, how much of the program recovery actions could you budget or fund within that flexibility? It balances to zero by intent, as it did in the fiscal year 1986, because there is an inherent assumption that there would be a full supplemental in fiscal year 1986 which included approximately $500 million for what we call the investigation and the anomaly resolution, primarily our preliminary estimates of the SRM fix as well as actions that may come as a result of the critical item list reviews.

Senator RIEGLE. Now, if I understand what you have just said, then you are saying that, well, you thought that with internal savings you could balance out the cost of, the extraordinary cost of the accident, that in addition to that you expected to get $500 million for fixes. Is that right?

Mr. STEEL. Yes, sir. Our estimates were $500 million in addition to the hardware replacement, which in total represents approximately $3 billion that we would propose as a supplemental.

Senator RIEGLE. Now, is this the current—is this the best estimate we have now, or is there a new one, and if so, do you have it with you, and can you tell us about it?

Mr. STEEL. This happens to be the best estimate we have. Unfortunately, it is based on the 12-month standdown, based on a more optimistic flight rate buildup than Admiral Truly just mentioned. We do not have the estimates that would accompany an 18-month standdown.

Senator RIEGLE. Now, this is where we start to run into difficulty, because we have obviously got to get a better handle on these numbers, and now those numbers are based on the assumption that we are shut down for 12 months. Is that right?

Mr. STEEL. Yes, sir.

Senator RIEGLE. I cannot find anybody, unless maybe one of the three of you at the table, I cannot find anybody else that really thinks that the 12-month shutdown estimate is the most realistic and proper one to make. Most people, virtually everybody that is associated with it publicly, and almost everybody privately is saying that we are going to be shut down longer than that.

Now, if we are shut down longer than that, how do these numbers change if we were to go, say, from 12 months to 18 months? Does that have a material impact on these numbers?

Admiral TRULY. Let me comment first, Senator Riegle, and then go back to Mr. Steel. I have in the same assessment in which I have recommended, but it has not yet been approved by the agency, what I believe is a realistic flight rate. We have also assessed in our SRM redesign effort the time that we think it is going to take to get back to first flight. My recommendation has been that it is going to take primarily about until the neighborhood of the summer of 1987, which would be about an 18-month standdown.

Prior to this time, and up to the point at which that recommendation is either modified or adjusted, we have been careful not to change our two planning estimates of the 12-month down and the 18-month down because we did not really have the answer. In my opinion, the 18-month approximate time to first flight is driven not so much by the specific design of the fix, but of the certification and testing program that is going to have to prove that that fix is safe to fly.

Senator RIEGLE. But you cannot detach that.

Admiral TRULY. That is right, and we should not and cannot detach it, and so in a sense I am the culprit that has prevented getting realistic budget numbers, because I have insisted on getting a realistic test schedule before we changed what we already had, and as a matter of fact, the Acting Administrator has insisted that I do that. I think we are at about that point, and I have just shared my recommendation to him with you.

Senator RIEGLE. So basically then while we have still been operating on the 12-month notion, if I understand what you have just said, it really does look like summertime before we are going to be flying, and it is more like 18 months, and this article, which I am sure you have seen in *Aviation Week* that says that the Agency hopes to resume shuttle flights in July 1987 is basically accurate. Is that right?

Admiral TRULY. I have not had time to read *Aviation Week* in the last couple of months.

Senator RIEGLE. Well, it is a wealth of good information. Let me recommend it to you.

That is how we get the facts here.

Admiral TRULY. But, no, we have not set a new flight date. However, in my estimate, and the work that I have done with the team that is going to have to set a certification and test schedule, I believe that that is the best that we are going to be able to do.

Senator RIEGLE. That is the 18-month shutdown?

Admiral TRULY. Yes, sir; and I would like to say again that there are—we are making—that is a tough schedule to meet, but there is not a safety risk in it, because if we get into a test program and whatever fix we choose does not meet it, we will stop and regroup at that point.

Senator RIEGLE. And you should, and we would strongly want you to do that. But that indicates that, if anything, it might slide past the 18 months, that it is not certain that we can make the 18 month figure.

And so do we have—do you have any kind of second unofficial estimate, if you will, that would assume shuttle downtime of 18 months, so that we can see how the numbers change under that kind of an assumption?

Admiral TRULY. Some months ago we did have—we do have in place an 18 month down manifest. However, at that time the budgetary—the assumption was made by the agency to base our initial estimates which you have on the 12 months down.

The process that needs to happen now, sir, is that at the agency level a downtime has to be agreed to, and you have my recommendation, as does Dr. Fletcher and Dr. Graham. And at that time we can then deal with another major problem, which is the competing expensive and crucial payloads both of NASA and the Department of Defense and other people, to set a manifest in place.

And we are at that point, and so as soon as Dr. Fletcher can concur or change my recommendation, he can set the wheels in progress, I think, for us to begin to improve our estimate. At the same time, as you pointed out earlier, there are major national decisions that need to be made concerning the replacement orbiter and the supplemental, and that these things I think are beginning to fall into place.

Our effort within the Office of Space Flight is to provide this initial data to the system.

Senator RIEGLE. Well, we need that as soon as you can get it. It sounds to me like the wheels are turning, but I would hope that within a couple of weeks here, in light of what you have said, that the decisions, those judgments, can be made and we at least get the cost estimates so that we can start to do better cost planning here.

Let me move to a different area. Rockwell has indicated in a recent briefing that they did on the Shuttle Spares Program that they could only support a flight rate of eight to nine flights per year. And I think last year we got nine flights, and so that seems to be in line with what our past experience had been pre the accident.

Now, in that flight rate estimate by Rockwell, who of course is the prime contractor on the shuttle or on the orbiter, it was that that would hold until 1989. Now, I would like your comment on the position that they have taken.

It seems to me that they are talking about a far more conservative flight schedule out through 1989 than what you are anticipating, and I would like you to address it directly.

Admiral TRULY. I am not familiar directly with that Rockwell estimate. I can comment and then maybe Mr. Steel could help me.

During this downtime, we are taking a hard look at our logistics chain and both at our Centers and through Rockwell to the Cape, to make sure that we can support these efforts that I have talked about. We have a logistics program that is in progress, and a part of the building blocks that I have received from the Level II organization were a status of the logistics.

And it was basically based on their recommendation that we felt like we could build up at these rates by taking action, among many other things that we have to do during this downtime, to assess and improve our logistics situation.

And so I believe that these rates are supportable.

Senator RIEGLE. Well, let me just tell you, my time is up for now, but I am very uneasy about the fact that there should be that kind of wide variance and view as to what constitutes a sustainable flight rate out into the future by NASA on the one hand and Rockwell on the other hand.

This in a sense reminds me of differences of opinion that we learned about after the fact with respect to the *Challenger* launch. But this is a fundamental question as to how fast we can go here, and the one thing—I just make this final comment before yielding, and that is that I think we really have to err on the side of conservatism in all of our estimates here.

I think the worst thing NASA could do right now is to try to float exaggerated expectations, whether it is in terms of flight rates or being able to get the job done with less money or anything that would tend to not prove out. I think one of the most important things NASA has to do right now—and you have to give us this so that we can help you get the job done here—and that is you have got to give us absolutely practical and realistic assessments.

And we cannot err, I think, on the side of too much optimism or we are going to hurt the credibility in another area. And I do not think we can afford that now. And so if there is a push to be optimistic in these areas, I think you and the others have to resist that, wherever that pressure comes from.

And I think we have to hold to levels that we really believe we can attain and that we are not going to set everybody up for a lot of disappointments or the view that we do not know what we are talking about.

Admiral TRULY. I could not agree with you more, sir. And with your permission, since I am not familiar with that particular thing, I would like to supply more information for you for the record.

Senator RIEGLE. Very good. I would like to have that.

[The following information was subsequently received for the record:]

Last October, in order to support development of the fiscal year 1987 budget, a detailed logistics review took place at Rockwell between representatives of JSC, KSC, the Office of Space Flight, the NASA Comptroller's Office, Rockwell logistics personnel and Rockwell senior management. The purpose of the review was to assess the adequacy of the logistics program to support planned flight requirements. Detailed assessments were made of authorized and anticipated spares by line item as well as vendor repairs and logistics management manpower based on the best understanding of failure rates, life limits, and repair times available at that time. It was concluded by Rockwell that the budget supported an 18 per year flight rate with adequate repairs and management manpower and by fiscal year 1991 achieved a 90-percent Probability of Sufficiency on the major spares items. Rockwell also concluded that for those items falling below the 90-percent level prior to fiscal year 1991 there would be a moderate risk which, if required, would be alleviated through increased cannibalization.

Both JSC and KSC performed independent assessments of the Rockwell program and identified the specific spares that were at risk for a 24 per year flight rate. Their conclusion was that the risk was manageable due to implementing a centralized repair depot at KSC and through judicious cross utilization of vehicle assets.

The contention that the current budget only supports an 8–9 annual flight rate and that there is significant risk for a 12 per year rate are not consistent with the analysis done by both contractor and center personnel. In October, Rockwell said they could support the fiscal year 1986 budgeted flight rate of 14 at an estimated cost which was within 3 percent of the planned budget availability. The planned fiscal year 1987 investment in spares inventory of 63 million adds confidence in the logistics program's capability to support higher flight rates. The program is being reviewed since the accident to reflect the loss of an orbiter, the lower flight rate, and probably a more conservative approach toward cannibalization and spares utilization.

Senator **Gorton**. Chairman Danforth.

The **Chairman**. Admiral, would you just recap for me these accidents that we have had. Would you recap for me what we have to do to replace what has been lost? I take it that the position of NASA is that we need another orbiter, is that right?

Admiral **Truly**. Yes.

The **Chairman**. And what would be the total cost of replacing the orbiter?

Admiral **Truly**. If I remember, it is—$1.9 billion was the figure, but that included replacement of three engines and some equipment that we lost in the orbiter itself.

The **Chairman**. And then, in addition to the orbiter, we lost the solid fuel rockets. I mean, is that included in the $1.9 billion or is that separate from it?

Admiral **Truly**. The $1.9 billion would replace the orbiter itself plus the orbiter-related equipment, equipment that we lost, the support equipment.

The **Chairman**. Everything that was lost in the disaster?

Admiral **Truly**. Except for the satellite, the tracking data and relay satellite that was in the payload bay, and the IUS, upper stage that was to carry it to orbit.

The **Chairman**. What is the total budget to replace the assets lost in the *Challenger* accident, along with the assets lost in the accidents of the Delta and Titan ELV's?

Admiral **Truly**. Let me see if I can respond to your question. I think Mr. Steel can respond better than I as to the numbers on the *Challenger* accident itself. The accident that we just suffered on the Delta presents us with, after we get the accident investigation done and take whatever action that is required to assure ourselves that we should refly Delta, we do have a number of Delta vehicles that are already manufactured and three that are partially manufactured, and it does give us the opportunity to look at that program and reassess it.

It would be NOAA's business as to whether or not they took action to change their present GOES satellite system, and I think Dr. Calio is going to be here to testify to that today. And I cannot speak to the third accident, the Titan 34D accident, because it is a DOD Program and I just do not know those numbers.

Other than the $1.5 billion, though, for the *Challenger* accident, I would defer to Mac.

Mr. **Steel**. Well, I think, Senator Danforth, the best way is to just summarize relative to the *Challenger* accident. We are proposing supplemental funding in approximately a total of $3 billion.

This is made up of approximately $500 million, $350 to $500 million, our current estimate, to both fix the SRM problem, the redesign and requal, whatever is necessary.

The **Chairman**. This is to fix the solid fuel rocket problem?

Mr. **Steel**. Yes.

The **Chairman**. By fixing do you mean correcting the problem so that it never occurs again, as opposed to simply replacing the solid fuel rockets?

Mr. **Steel**. That is exactly right.

And in addition to that, the $350 to $500 million also includes an estimate as best we can arrive at right now to take care of any actions that may come out of the overall system review going on with regard to the items on the critical items list.

In addition to that $500 million, we are estimating about $2.5 billion, which includes the $1.9 billion that Admiral Truly mentioned, for orbiter and related equipment, as well as $450 million for a Replacement Structural Spares Program, if you will.

The CHAIRMAN. For what?

Mr. STEEL. To replace the Structural Spares Program.

The CHAIRMAN. I am sorry, I cannot hear you.

Mr. STEEL. The Orbiter Structural Spares Program, one which will allow us to build a replacement orbiter in roughly 36 to 42 months, as opposed to something that would normally be a year to a year and a half later.

That has been a program that we have been funding since 1983. We would recommend that we, if we proceed with the replacement orbiter, also start a new Structural Spares Program.

All of those items are in that $3 billion.

The CHAIRMAN. All right. Now, focusing on the $350 to $500 million for the solid rocket boosters, these are the rockets that have been used time and time again, is that correct?

Admiral TRULY. Yes, sir.

The CHAIRMAN. In other words, you send them up, they are recovered at sea after they have been used, and then they are refurbished and sent up again. And as I understand it, now you are analyzing the cause of the SRB failure?

Admiral TRULY. Yes, sir. We are working hard to make sure that we can pin down the probably cause of the accident and that we have localized it to one of the joints in that motor. The motor is built in case segments. The failure was in that joint.

We will have to assess various fixes to that and determine a fix, and then certify and test for reflight.

The CHAIRMAN. I understand. Is the concept of the reuse of these solid fuel rockets, is that being questioned? In other words, is there any doubt in your mind or any one else at NASA that the concept of reusable, recyclable rockets is a good one?

Admiral TRULY. There is no question in my mind that the concept of reusing the solid rocket motors remains a viable concept. However, I think we will have to await the work of the Presidential Commission and see if they have recommendations in this area.

But at this point, this tragic accident has a lot of bad sides to it, but I do not see anything in it that would prevent or would make me think that a careful post-flight inspection and refurbishment of the case segments would still not be a viable thing to do.

The CHAIRMAN. Let me ask you about the point that Senator Gore has made with respect to the quality assurance personnel and the story that was in the Washington Post this morning. It would appear that there has been a dramatic reduction in quality assurance personnel.

Do quality assurance personnel inspect equipment and make sure that everything is in working order?

Admiral TRULY. That is correct. Quality assurance personnel are generally people that, at various levels of the assembly and manufacturing process, that certify the quality, assure the quality of the part in question.

The CHAIRMAN. Is this true, that there has been a substantial cutback in quality assurance personnel? And if it is true, why has it happened?

Admiral TRULY. I am afraid that I am unprepared this morning to discuss it. But let me say two things. I would like to take for the record and pass this back to the chief engineer's office, under who the Quality Assurance Program is run, so that we can properly respond.

I would also like to say that earlier I mentioned an overall strategy for us to return to flight that required us to look to various areas of our program, to reassess them. And the entire tenor of that strategy includes a conservative and safe approach. This subject quite clearly would fall under that umbrella for us to relook at it during the down time, and we will do that.

[The following information was subsequently received for the record:]

R&QA CS PERSONNEL CHANGES OCTOBER 30, 1970–AUGUST 31, 1985

Installation	October 30, 1970	August 31, 1985	Change
Headquarters	23	16	−7
ARC (includes DFR)	29	9	−20
GSFC (includes WFF)	307	102	−205
JSC	219	79	−140
KSC	316	145	−171
LARC	121	37	−84
LERC	17	29	+12
MSFC	562	88	−474
Total	1,594	505	−1,089

The CHAIRMAN. As far as we are concerned in Congress, of course, we are going to have to address the question of, in an age of budgetary constraints, how much money we can give to NASA to replace equipment and develop new equipment. But is it likely that there are going to be significant personnel costs as well?

That is, are we going to be faced with decisions to hire significant numbers of quality assurance personnel?

Admiral TRULY. I do not know, sir. The reassessments that we are talking about are complex and they are going to take some time to do them right. And I think that we must take the time to make sure that we make the fixes both in people and in new capability and in hardware that are prudent and that we can afford.

But it would be premature for me to say, to answer your question directly.

The CHAIRMAN. Thank you.

Senator GORTON. Senator Gore.

Senator GORE. Thank you very much, Mr. Chairman.

Admiral Truly, all of us wish you the best in your new assignment, and the entire country has such great hopes that NASA will quickly recover from these dark days.

I would like to pursue the line of questioning just begun by the full committee chairman about the reductions in quality control personnel, which I talked about in my opening statement. First of all, do you dispute any of the figures that I have provided to you this morning?

Admiral TRULY. I am not familiar with them, sir. I do not dispute a one, nor can I confirm them. It is a subject that I also read the Washington Post this morning and I was not prepared. I did not prepare myself to answer for the chief engineer, or to invite him to the hearing.

Senator GORE. Well, do you have a separate line item for quality control in your budget? I think the answer to that is no, is it not, Mr. Steel?

Mr. STEEL. We do not in the Office of Space Flight.

Admiral TRULY. Not in the Office of Space Flight. But as you know, the Quality Assurance Program has to be built into the system. And the very nature of it requires that we who are program managers should not provide the people that would inspect our products.

And so, even though it is not my personal responsibility within the agency, this program, it certainly is a focus that we will assess. And if there are differences in the figures or things to understand about them so that you can assess them, we will do that.

Senator GORE. Well, it not only has to be built into the program; it has to be a top concern of central management.

Admiral TRULY. You are absolutely correct.

Senator GORE. And I would encourage you to have a separate breakout so you can track this function, because what happened over the last 10 to 15 years is in my view a disaster.

You mentioned in your statement, or I guess in response to one of the early questions, that you knew of nothing to indicate that this recent string of failures was anything more than coincidental in terms of a common cause or a common factor.

Admiral TRULY. That is correct.

Senator GORE. In my view, it is likely that when the investigations are all complete there will be a common factor, and that is a decline of quality control. Do you think that is a reasonable speculation or not?

Admiral TRULY. It may be. But I am afraid I am from the school that says that we should let the accident investigation teams conclude and then take their evidence before I would comment.

But certainly, if there are—some of these accidents certainly could be, could have a principal cause of quality, either in the factory or in assembly. Some I think may very well be a design problem, particularly in the *Challenger* case.

I think that we—as I testified earlier, most major accidents are caused by a chain of events. Quality may very well be in that chain in these accidents. However, I predict that it will not be the only thing. Design or simple—well, design may very well be.

Senator GORE. Well, the design was not the problem with the Delta rocket. We had 43 successful launches in a row, and then an 18 month hiatus and then a failure.

Where is the Delta main engine inspected and tested?

Admiral **Truly**. I will let Joe speak to that. But sir, in this business I would not rule out a design problem no matter how many flights we have flown. I think that that is a reasonable early guess, but that is why we have an investigation team. And if quality is the problem, I am sure they will find it.

The engine is a Rocketdyne engine, but I think Joe could speak to that.

Mr. **Mahon**. The inspection is done at Rocketdyne, and it is actually tested for flight. It is fired to establish what we call tag values for the performance in flight, in which we judge it.

Senator **Gore**. Where does NASA inspect it?

Mr. **Mahon**. NASA has a whole series of inspections.

Senator **Gore**. Where?

Mr. **Mahon**. At the Rockwell plant.

Senator **Gore**. How many employees are at the Rockwell plant involved in quality control?

Mr. **Mahon**. There are none to my knowledge at the Rockwell plant that are NASA inspectors, but that does not prevent them from going there and visiting them at the time of the vehicle buyoff and going through the paper and processing the plant equipment.

[The following information was subsequently recieved for the record:]

As of January 1986, the number of quality assurance people at the Rockwell plant is 324: 12 NASA; 17 DCAS; and 295 Rockwell (for JSC).

Senator **Gore**. Going through the paper?

Mr. **Mahon**. Yes. You see, one thing, sir, that you may not understand is that we depend upon the DCAS, the Defense Communications Assistance, for inspection services in that regard. And there are military residents in there and, rather than duplicate the military inspection service, we have them perform that function for NASA.

So in effect, they are working for us as it goes through the plant in this process.

Senator **Gore**. Well, let me tell you what the past commander of the Army's Ballistic Missile Agency has said about this procedure of quality control through looking at the paper. This is a quote from General John Maderas, who used to command Redstone. He said:

"The way they have structured the work"—speaking of NASA—"nobody is really able to have clean lines of communication that we have and thereby pick up immediately anything that may be wrong. What they call quality assurance is shuffling a bunch of papers, reports from contractors. But that is not quality assurance. That is nonsense."

Would you agree with that statement?

Mr. **Mahon**. I would agree with the statement if that were the only function that the quality assurance people are performing. What I pointed out was that there are resident in-plant inspectors which we were paying for to perform these various inspections as the piece is being made and processed through the plant.

Senator **Gore**. Did you ever encounter quality control problems with the Delta before?

Mr. MAHON. Yes, sir, at many times through the system. One of the things that we originated in the Delta Program was a Parts Screening Program that we developed to ensure that we got highly qualified parts in electronics. And we have gone through exercise systems ~~like~~ this throughout the subsystem arena so that we can maintain the record that we did get.

Senator GORE. Well, it is my understanding that one of the earlier versions did have a lot of quality control problems, but this latest version was proved out pretty well up until the hiatus occurred.

Is there a specific NASA Center that has responsibility for testing the Delta engine or assuring its quality?

Mr. MAHON. The answer to that is yes, the Goddard Space Flight Center and the Delta project office is responsible for the conduct of the Delta Program.

Senator GORE. Has the 65-percent reduction in quality control personnel at Goddard had any impact on your ability to assure the quality of the Delta main engine?

Mr. MAHON. Apparently—well, personally, I have not felt any degradation of quality inspections being performed by the staff. I was not aware of the numbers either.

What we think—I would like to point out that in many cases here we had five and six ELV programs going. Some have been already phased out and there have been associated inspections and quality people that was no longer needed to the programs that are phased out. Some of them may be included in that number of reductions.

Senator GORE. Well now, the SRB is the responsibility of Marshall, correct?

Mr. MAHON. Yes.

Senator Gore: Do you think the 86 percent reduction, as depicted on that chart, in the quality control personnel at Marshall has had any impact on your ability to assure the quality of the SRB?

Admiral TRULY. As I said, sir, I have not had an opportunity to assess the numbers and determine that. But I can assure you that I will make sure that the right people do that for the record and get back with any questions that you have.

Senator GORE. Do you know how many positions for quality control are reflected in your January budget request?

Admiral TRULY. No, sir, I do not.

Senator GORE. Could you provide that for the record?

Admiral TRULY. I certainly will. And the reason that I do not know it is that it is not a part of the Office of Space Flight's budget.

[The following information was subsequently received for the record:]

It is important to discuss the reduction in civil service R&QA personnel in the proper perspective. Please note that the highly publicized "reduction" concerns only civil service R&QA personnel. The "70 percent reduction" over the past 15 years included many functions such as metrology/calibration, parts, assemblies and systems testing, material testing, chemical analysis, etc. which were in the 1970 R&QA organizations but transferred to other organizations within the NASA centers. Also, included in the "70 percent reduction" were in-house flight programs such as Viking, Saturn launch vehicles and Skylab Apollo Telescope Mount which require NASA inspection/verification on manufacturing, assembly and test operation. The termination of these in-house flight programs, along with the transfer of certain functions, accounts for much of the "70 percent reduction."

Using the same functional baseline, the number of R&QA personnel in 1970 was approximately 1,030 out of a total population of 32,500. In 1985 we had approximately 580 R&QA personnel out of 22,300 employees. Over the 15 years, NASA had a decrease of approximately 10,200 employees of which 450 were in R&QA.

However, this total reduction of 450 R&QA people includes the reduction in program content for the agency which is represented by the overall population decrease from 32,500 to 22,300 as well as an effective real decrease in R&QA coverage on the remaining programs. This effective real decrease in coverage can be determined by comparing the percentage of NASA R&QA of the total population in 1970 versus 1985. In 1970 we had 3.2 percent of the employees in R&QA, while in 1985 we had 2.6 percent. The decrease in R&QA was 0.6 percent or approximately 135 people. This means that of the 450 drop, 135 represents a decrease in *coverage* while the remainder of the 450 (315) represents a decrease because of total program content reduction.

Even though we had a reduction in R&QA personnel, our detail review of the quality operation did not reveal that we missed any of the quality control check points which may have contributed to the accident. We firmly believe that the checks and double checks by NASA personnel, our Government QA Specialists, and our contractor QA personnel were adequate. We are reassessing the entire quality operation for the purpose of identifying ways we can strengthen the system. This reassessment will include a study of the staffing in SR&QA.

Senator Gore. Now, is it true that critical quality control measures, including testing, were eliminated for the shuttle main engine, for the heat-absorbing tiles, and for the tires and landing system?

Admiral Truly. I am not familiar with that, but again I will look into it and reply to you.

Senator Gore. Well, I am informed that all three of those quality control procedures were drastically cut back and that as a result there has been a real degradation in performance of the main engine, needing overhaul after only 5 flights instead of 55 flights.

The failures of the heating tiles are of course well known because of all the publicity about them. And if I am not mistaken, there have been serious problems with the tires and landing gear as well, even to the point where the astronauts now cite that as one reason for not wishing to land at Kennedy Space Center any more in the Shuttle Program.

You mentioned that you wanted to get to your chief engineer to get his view of this matter. Dr. Silveira is his name. He was—well, I will come back to this question in the next round.

Thank you.

Senator Gorton. Senator Hollings.

Senator Hollings. Thank you, Mr. Chairman.

Let me ask just exactly perhaps a question that was about to be asked. Dr. Silveira, the chief engineer, has submitted to Dr. Graham over 2 months ago a group of safety recommendations, Admiral Truly. Now, those recommendations have been referred to in *New York Times* articles, *Aviation Week*. Everybody seems to have a copy of them.

Can you furnish the subcommittee a copy?

Admiral Truly. I will certainly try to find out precisely what you want and get them.[1]

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[1] The submission was not reproducible and is in the committee files.

Senator HOLLINGS. Well, there is no vagueness about what I want. And we have got to re-establish credibility and support for NASA, and so do not act like they are some nebulous thing and you have got so many reports that you cannot understand what I am asking about.

Dr. Silveira, NASA's chief engineer, made safety recommendations, about 30 or 40 pages. If you want me to describe it, I can describe it for you. I would like to get a copy of it for the subcommittee. Can you do that for us?

Admiral TRULY. I will do my best to get what you are asking for, sir. The chief engineer writes memoes on safety, because that is his business, on many issues. I am just not personally familiar with this particular one, but I will certainly do it for you.

Senator HOLLINGS. Well then, do it this way. Just furnish us all his memoes since the *Challenger* disaster, since the 28th of January. He could not have written that many. Just get that one, plus any and all others.

Admiral TRULY. I will pass that request directly to him, sir.

[The following information was subsequently received for the record:]

NASA,
Washington, DC, March 24, 1986.

To: A/AD/Acting Administrator.
From: D/Chief Engineer.
Subject: Additional Efforts Proposed by the Office of the Chief Engineer.

Enclosed is a list of tasks which I believe are necessary to improve the flight program reviews and to increase the confidence in flight hardware. I request your approval to continue plans for performing these tasks and to coordinate these plans with the appropriate Associate Administrators.

We are also working the estimate of staff and resource increases which can be better prepared with your approval to continue planning. We will attempt to use primarily OAST center people to augment our staff where possible to accomplish the tasks necessary for the next Space Shuttle launch.

MILTON A. SILVEIRA.

Senator HOLLINGS. I would appreciate it.

Senator RIEGLE. Senator Hollings, would you yield at that point?

Senator HOLLINGS. Yes.

Senator RIEGLE. I think we have to have that, and I do not think you are trying to sort of sidestep us here, but I would like to just say to the chairman if I could for a moment, I think Senator Hollings'request that we get a copy of that memo on the internal safety change recommendations that have been made officially by the person in charge of that for NASA and which is in a written form—it has been referred to in a number of places.

I think we have to have that, and I think we have to have it without delay. And I would hope that the committee could ask for it officially, because I think it is in our interest to do so, but also to strengthen your hand in getting it. I do not want to get the bureaucratic run-around here, and I know Senator Hollings does not.

And if this is available and it is being looked at, I think we have to see it and draw what conclusions we can from it. And so I guess what I would like is either a firm commitment from you that you will have it to us here within a matter of days, and if you cannot give us that commitment then I would like to ask the chairman if we could not make a formal request on behalf of the committee to get it, without any ifs, ands, or buts about it.

Senator GORTON. That sounds like a reasonable position to the chair.

Senator GORE. If Senator Hollings would yield further on this point, let me just say that I had a really difficult time getting the figure that I talked about this morning on quality control, and eventually went around the apparatus that NASA has for dealing with the Congress and posed the question directly to someone down in the bureaucracy who had the actual figures.

And this person responded candidly, but became rather nervous about it. And I would like your personal assurance, Admiral Truly, without any implication that it is really necessary, but nevertheless, for this person's, for his own sense of wellbeing, I would like your personal assurance that there be no retaliation against employees providing information to members of the subcommittee.

Admiral TRULY. I would like to respond in general. I do not want this subcommittee or any other body of the Congress to think for a moment that I, and to my knowledge other members of NASA, are not making an attempt to meet our obligation to you in your oversight of our programs in any manner that I know of.

I do know in my personal experience, and I have no experience with this particular issue, that we are in a situation where many times we are getting requests from the Congress, from the Presidential Commission, and from Freedom of Information Act requests, all of which we are trying to legitimately respond to.

I have spent many hours on this subject and trying to cope and to respond forthrightly, even in documents that may not represent, or that may be damaging in the media, and may not represent agency positions. But nevertheless, I have personally, and I have watched the other members of the NASA management as we have attempted to deal with this situation. I will make every attempt to help in this particular situation. But I think it may be more circumstance in some cases than what may appear to you to be intentional delay.

Senator GORE. Well, can I have your assurance that this individual will not suffer any retaliation?

Admiral TRULY. I do not know who he is, sir.

Senator GORE. Well, I am not going to tell you, particularly without the assurance. But assuming that you find out who it is, can I have your assurance that the individual who has provided me——

Admiral TRULY. Of course.

Senator GORE. All right. That is the answer I am looking for. Thank you.

Senator HOLLINGS. Slade, give me a couple of more minutes.

I have got a lot of things, one about the budget.

Senator GORE. I will yield some of my time to Senator Hollings.

Senator HOLLINGS. But I am anxious about the budget, and that is the purpose of the hearing. But I have got to jump quickly, and so if you run out of time on this answer I will at least get that answer before I come back to the budget.

Specifically let me ask, Admiral Truly, will you allow Mr. Steel over there about $800,000 for a testing of a solid rocket booster by one of the solid rocket motor contractors? I know not which one.

But I understand there has been alternative or second source proposals made to NASA for the construction of a solid rocket booster, a monolithic motor, at the site in Florida.

And in order to get that testing made and everything else all over again to fit into this $350 million repair of the particular difficulty that we had with the *Challenger* SRB's. It only costs about $800,000 and I am wondering if this option will be assessed.

And the background of that question specifically goes to all of the reports—we read them in the newspaper—that, after all, Dr. Fletcher was from Utah, he was president of the university and knew the Mormon crowd out there, and he also married a Utah citizen. These reports also note the chairman of the space committee in the Senate at the time was from Utah and it was a Utah conspiracy that got Morton Thiokol into this, and they did not even pay any attention to the solid rocket booster; that is why it is segmented, that is why we have an O-ring problem.

And right to the point, last evening, a man came up to me and said exactly the same thing was happening all over again. He said: We are trying with SRB's, but you have confirmed Dr. Fletcher, and they will not even let us participate. And if we could get, out of this $350 million supplemental, about $700,000 or $800,000, we could prove, because we have proved before—we have had three solid rockets made and tested and passed the test, and this is 15, 20 years ago—the technical merit of a monolithic SRB.

And he said, we could reinstitute this particular operation down in Florida. You would not have to ship them in parts. You would not have an O-ring problem and a weather problem and everything else like that.

But the Utah conspiracy will not even let us in, and that kind of thing.

Now, that sounds like fanciful nonsense, but it has also got some substance to it, and that is why I asked the question. In all the hearings so far that I have followed with the Rogers Commission, they knew of the O-ring problem, it had been a criticality 1, they had special hearings in August a year ago.

They were so distraught that they could not find a solution that they even attended automotive engineering seminars in November of last year to see whether the automotive engineers had any kind of approach to the O-ring problem. They did not have any, and no one else has.

And here comes a valid contractor saying: Look, we can test a solid rocket booster and you do not have any O-rings, period. Do not call it solid when it is not solid. We will give you one that is solid and the problem is solved.

And that is why I am back now to the bottom line question. Out of that $350 million proposed supplemental, are you looking at an alternative source that truly presents a solid rocket booster, so we will not have that particular problem?

Admiral TRULY. We have had prior to the accident a second source effort in place. I think I am familiar with the unsolicited proposal that we received from a single contractor that you are referring to.

Senator HOLLINGS. That is right, Aerojet or Hercules or United Technologies.

Admiral TRULY. I believe this particular one was Aerojet. As I understand that particular proposal, it is a proposal for about a three-quarters of a million dollars study. It would be my intention—and we are internally very actively continuing to look at the general area or the question of second sourcing.

And I can tell you that in general I think that every government agency should consider second sourcing where it is proper in a dollar sense and a performance sense to the issue involved.

We are not to the point, frankly, where—with the accident investigation in place in the Office of Space Flight, we have not had the time to totally consider this issue of second source. But it is in progress right now. I think what we should do is take a look at the various initiatives that have been made, not only by that contractor, but some others, and the effort that we had in place before, and decide what sort of second source approach that NASA should take.

And we should go out and compete it, not going to a single contractor, but go out on the street with a clear request, considering the aftermath of the accident, and give the solid rocket motors, wherever they come from, the opportunity to compete in the marketplace for that.

Senator HOLLINGS. That is competition for a better putty. That is competition for a better ring. That is competition for a better joint. Now, I have heard the best of the best come up and say: We could not find the solution to a better ring and a better putty, and all of those things.

What I am saying is eliminate the problem. Why not, out of the $350 million—you just testified $350 million to repair and find a solution to this particular problem—why not spend three-quarters or $750,000 if you have got a contractor—get two contractors down in Florida at the site. That is where the competition should be for a particular design.

You said it was a design defect. I say it is a design defect. Let us get rid of the design defect and put the competition at the source and get two of them on the solids, but make sure the solid is solid. That is my point. It seems like we can solve this problem.

You have got a tremendous disaster on your hands and you are trying to rebuild. But you tippy-toe all around an obvious, logical solution.

Admiral TRULY. Sir, there are points to that solution that are now obvious or logical.

Senator HOLLINGS. What are they?

Admiral TRULY. That particular proposal would build a solid rocket motor that weighs 1.3 million pounds, that cannot be moved except by barge. It would require facilities to erect it, to test it, that are not in place.

Senator HOLLINGS. Well, I understood they had some facilities that were erected and were in place.

Admiral TRULY. And we will consider their proposal. But I guess to honestly respond to your question, I do not subscribe to the statement that we cannot fix our problem, and since we know where the design defect is. But I can assure you, on the general subject of the second source and on the specific proposal that this contractor has made, we will seriously look at it.

I just think that we ought to decide what approach we think is prudent for the agency and for the country and for the budget.

Senator HOLLINGS. Well, that is all I am asking for. I do not have any interest in this company. But you get the entire solid rocket motor built right in Florida and barge it to KSC. That would be a requirement, and then we would not have any O-ring, we would not have any field joint. We would not have them saying, well, it was a design defect, it was cold that day, they had to fight and push and pull, and we never did know whether they really got it together on that morning ready to go and what have you, because it was construction crew's negligence or whatever.

You see, all of that goes out of the window if there is a monolithic solid rocket booster. And I think you have got to open up your minds and get a second source and get rid of that joint. This country is not going to stand for any more joint problems, I can tell you that right now.

Senator GORTON. Senator, I think we will now do a second round.

Senator HOLLINGS. All right. I will come back to the budget.

Senator GORTON. And then I think we will have to go on to our next witnesses.

You did tell, I think, Senator Gore that you have not had a chance to read a number of these outside publications, which we of course do. But I understand that this morning's edition of Aerospace Daily quotes an unnamed NASA official as saying that improper engine welds and cracks in fuel pump blades have been coincidentally discovered in the shuttle main engines; and that, since these improper welds and cracks exceed NASA safety margins, the shuttle fleet would have been grounded even if the shuttle accident had not occurred.

Are you familiar with this discovery of improper welds and cracks? And if you are, would they have required the grounding of the shuttle fleet?

Admiral TRULY. I am familiar with some problems and turbine blade cracks on some of our, as I understand it, some of our long life high-power engine testing. They were being—they were, as I understand it, they were being looked at at the time of the accident.

And in our criticality 1 review, we are specifically looking at the turbine blade problem, to address it as to whether or not what testing and what decisions need to be made prior to getting back into flight. And we have not made a decision on that.

Senator GORTON. Would this have grounded the shuttle even in the absence of the *Challenger* accident?

Admiral TRULY. I do not know the answer to your question. The problem, as I understand it, showed up just shortly before the accident, and I really do not have the information to comment directly.

Senator GORTON. On a similar subject, that same NASA official indicated that, for the sake of safety, NASA should fly at a power thrust level of 100 percent rather than 104 percent, and that a three-engine cluster test of the shuttle main engines is unnecessary.

I recognize that flying at a lower power thrust certainly would cut down on payload. But are we allowing a sufficient margin of safety flying at 104 percent?

[The following information was subsequently received for the record:]

In the history of the Space Shuttle Main Engine (SSME) Program there has been four 2nd lobe fir tree cracks in about 4,000 blades tested; or about one in 1,000. In April 1985, a crack was found in a pump that had only 752 seconds on it. The disposition at the time was that there was a calculated 1.3 (at 104 percent) factor of safety (F.S.) even with the second lobe cracked all the way through. To verify the calculated F.S., a spin test was planned. On March 7, 1986, a spin test came out 1.3 at 104 percent and 1.23 at 109 percent. When the negative effects of H2 degradation are included, the factor of safety drops even more. The questionable aspect was that the test was not totally simulating real blade engine firing exposure. The crack occurs during the first test on the turbine wheel and is, therefore, an infant mortality problem.

There are four methods of resolving the concern:

(1) Perform a realistic spin test and confirm a higher F.S.—to test summer 1986.

(2) Test such set of blades twice; inspect for cracks. If no cracks are found, then the pump could be re-green runned and flown for at least eight flights.

(3) Shot peen fir tree to increase strength—to test summer 1986.

(4) Single crystal blades for higher strength—to test fall 1986.

There was the possibility that with the time constraints and the potential testing required to weed out the infant mortality blade crack problem, that flight delays would have occurred.

Admiral TRULY. I think it is proper to make decisions as to what percent we fly based on testing. We have flown, I think, if I remember correctly—of the 25 flights, I think 15 of them have flown at 104 percent. We have an engine test program that started even prior to the flight, as you know, and it built up first from 100 percent to 104 percent. We have payloads that require 109 percent in the future.

We have a major test program to assure ourselves that we will be safe on the day that we commit to those, or we will not fly.

Senator GORTON. The subcommittee has a copy of an April 23 memo from NASA headquarters to Mr. Arnold Aldrich at Johnson Space Center that states: "With the exception of the $5 million modification effort for orbiter vehicle 103, you are requested to terminate any other orbiter-Centaur work that would require the incurring of any costs."

Does this indicate that the shuttle Centaur program may not be completed, or that there is a lack of confidence in the program's ability to meet necessary safety standards?

Admiral TRULY. That direction was in response to a letter that the agency received from Chairman Boland of the House Appropriations Committee. It is not an indication that the program will not proceed, and that direct action has not stopped any efforts that would be long lead efforts.

It does, however, bear directly on the agency level, the administrator level study that I mentioned in my verbal remarks earlier that I have turned on to reassess where we are in the shuttle-Centaur program, both from a programmatic—in other words, how much will it cost and can it fly and is it going to be safe, so that we can reassess those.

Senator GORTON. Those are all open questions at this point?

Admiral TRULY. They are open questions directly in this study. We have efforts going along in all those areas, primarily driven by a number of safety concerns that were being discussed about the shuttle-Centaur program at the time of the accident.

What I have done—and we have in place an almost yearlong independent safety study of the Centaur. In order to properly answer the Congress' direction and to reassure ourselves that that program is either on track or not on track and make an assessment as to the proper way to go, we have instituted this internal study that will come first to me and then to the Administrator, and then back to the Congress.

Senator GORTON. Also, a March 27 memo from you to NASA's Chief Engineer states:

> Safety performance of the shuttle-Centaur program in terms of meeting program ground safety requirements has been quite clearly less than desirable. Flight safety aspects have encountered similar problems, but those have had to be delayed because the ground activities obviously have had to precede those of flight.
>
> Other safety-related activities also cause concerns, either by their lateness or omission. There have been numerous waivers and deviations granted to the shuttle-Centaur vehicle from several requirements sources. At no time has anyone taken a cumulative examination of all of these waivers and deviations to examine the design and operational risks.

What do the comments really indicate about the Centaur program and any chances of ever successfully completing it within safety standards? Have you answered that question completely in connection with my previous question, or is this a major and serious matter?

Admiral TRULY. The Chief Engineer's office, along with us, will be party to this assessment of the shuttle-Centaur program. We will look at every aspect of it and reassure ourselves—or, not reassure ourselves, assess the program and respond to the concerns.

I could give you my personal view with the information that I have now, and that is that the safety concerns that were present and being worked at the time of the accident are being, have been and are being worked vigorously between our level II organization and the program office at the Lewis center; and that we have a plan in place that I believe will make the shuttle-Centaur a viable vehicle for its missions.

However, that is an opinion. What we need to do is gather all the parties to this issue together through a coordinated study, which is what I have set in place, and have them stand up and assess for us and for me to pass on to the Administrator what we think we should do with the program.

Senator GORTON. I will submit the rest of my questions in writing.

Senator Riegle.

Senator RIEGLE. Thank you, Mr. Chairman.

Admiral Truly, you have had a distinguished career on the military side and in NASA, and continuing now to the present time. I have really been struggling in my own mind about the fact that we now have two space programs in the United States. We have got the defense space program, which is now costing us about $15 billion a year, and the NASA space program, which most people think of as our space program, and that is at about $7 billion a year.

So in combination, we are spending about $22 billion a year on space. But I think what has happened here is that the defense space program has kind of grown rather quickly and has been much less in the public eye. And it seems to me that in a sense we are sort of going down two tracks here.

Now, people say we are really on one track, and my answer to that: If we are on one track, why do we not have a combined operation rather than two operations? But we have two of them.

And I am concerned that if we do not find a way to examine that question carefully, that we may find that NASA starts to get shaved in certain ways, and may already have been shaved in certain ways. There is only so much talent available to deal with some of these very complex scientific type, engineering type questions. There is only so much money, whether it is to go for quality assurance or other things.

And I am worried about whether or not we have got a divided effort here that in the end is not in the country's best interest. And I would like you to just give me your own reflections on that from the point of view of a person who can put different hats on to think about it.

Is this what we ought to be doing? Should we have two space programs, or three or four? Or should we think about maybe getting ourselves back to the point where we have one unified space program, we do not have multiple bureaucracies, multiple this, multiple that, tensions back and forth, budget pressures back and forth?

What are your thoughts on that?

Admiral TRULY. Senator Riegle, I think that is a very probing thought and question, and it is one that, as I recall, we discussed a little bit or touched on at a previous hearing.

Let me preface my remarks by saying that my response would be the same were I here representing DOD rather than NASA today. I personally think that it is in the Nation's interest to have a civil space program, and that it be separate from our national security program that is run by the DOD.

I say that because, even though at these times our problems seem so immense, the reason that—one of the reasons that they are so immense is that space contributes in so many different ways to the fabric of our national life. I see, frankly, the practical needs of DOD and national security, and they are many and they are expensive, and they are highly technical and needed, are so diverse from the opportunities that are provided through space of, in a civil program, planetary exploration, communications, weather.

You have asked me a personal opinion question, and my opinion is that, even though there may appear to be some dollar advantages—and there may be and there may not be, I am not sure. That would take a very detailed study.

I think on a national policy point of view, I would personally be very reticent to put my name to a recommendation that we meld the civil space program and the DOD space program into one.

Senator RIEGLE. Well, I am reluctant to do that, too, for much the same reason. I think the civil space program as you describe it is very important, and I think it needs to be maintained. Its integrity needs to be maintained in terms of its definition, its funding, its quality, its blend of missions, and so forth, but I have the sense that the defense space program is growing so rapidly that the civil space program is starting to become a little bit the tail on the dog rather than the other way around, and I think the dollars reflect that because of just the sheer enormity of the dollars involved here, and of course there is the cross-connection with the shuttle.

That is the only manned vehicle that we have or are going to have for a very long time, and that is, of course, really a NASA program.

When we get flying again, then anything that DOT needs that requires that kind of capability, they have to do that job with and through NASA, and so there are all kinds of cross-connections here, and I guess I am concerned that somehow we need to get a better handle on the dimensions of this growth and change, and I don't know how our subcommittee appropriately reaches to get our hands around a better sense of the defense space program, but I think now I am beginning to detect what my judgment tells me are spinoffs that are not necessarily positive ones on NASA from this giant defense space program growth, and I think we have to try to look at that question.

I grant you that is a very complex study, but you know, we are spending $22 billion a year here and probably more. And so it is not as if this is an incidental item. This is a major item in our budget, and it is a major national security item, as you properly point out. So, somehow, Mr. Chairman, I am not quite sure how we do it.

I think we have got to examine that question, because I think with the cost pressures of Gramm-Rudman-Hollings coming in as they are to reduce the deficits and other factors, I think NASA is being squeezed, being squeezed very hard, and I think you are being squeezed very hard by OMB, and I think one of the reasons we are not getting the shuttle replacement decision out of SIG is partly bureaucratic paralysis, inexcusable, but nevertheless I think that is a large part of it, but I also think it is cost pressure.

They do not want to come in and ask for the additional money, and so time is sliding by, and so forth, and I do not want to see NASA squeezed down to a point where it cannot properly do what a civil space agency needs to do. I think it is one of the most important efforts that we have going in terms of science and breaking through into new areas of knowledge, and I also think that with respect to competition, that is always there with the Soviet Government and others that we cannot yield ourselves into a second-place status, which is where we are right now, for example, with the space station, and so I would like further thoughts from you on this. I think this is an area that now has to be drawn into a tighter focus.

I want to ask you if in that same vein there has been some discussion in the trade press that the shuttle might have to be called back into service for maybe a strategic assignment if we should find ourselves with a national security requirement that cannot be met any other way and is thought to be urgently needed, and that there is a possibility, at least, that if that need arose we would go ahead and use it if we had to, whether or not the Rogers Commission recommendations when they are forthcoming had been fully implemented.

Is there any truth to that kind of rumor that is circulating?

Admiral TRULY. Not to my knowledge. My personal argument would be that if we had a national emergency that required a space launch, that it would be much more logical to do that on a Titan than on a shuttle, and I can assure you that I have received no direction or request from the DOD or from any source to consider such a launch.

Senator RIEGLE. So not only, not having gotten any direct recommendation, you have not heard any serious talk circulating in this vein?

Admiral TRULY. Certainly informally I have talked about it with some of my friends in the business. It obviously—who knows what we would do if the Nation went to war, but I can assure you that as far as I am concerned, the most important thing that we need to do to get assured access to space is the program that we are on, is to fix this problem that we have, and reinstill confidence in our safety and our ability to get the shuttle back in the air, and the way to do that is not a quick fix.

Senator RIEGLE. I have got a whole host of other questions, and I want to just move into one area, and that is that I want to talk to you a little bit about criticality 1 items, and I know this is a matter of very deep concern to you from your own personal history and so forth. I gather that in reviewing the criticality 1 items on the orbiter, that in terms of rough count there are 335 that relate to the orbiter; 94 main engine items on that list; 114 solid rocket boosters items; and the external tank has 133 items. And other parts of the shuttle apparently have 64 items.

And so there are an awful lot of items that have to be worked carefully by the teams that are doing that. Can you give us a status report on where this criticality 1 review process stands now, I mean, not so much into the guts of any of these areas, but as you are pursuing all of these areas, where are we in terms of that review and who is doing the job, too, may I ask?

Admiral TRULY. I can give you a brief summary, but I can respond much more definitively by going and checking the records. In general, the process is well underway. We are doing it. I have directed the level II organization at the Johnson Space Center to lead this effort, and in doing that they involve the level III project offices and the contractors, and if an issue is serious enough to go get either—well, we have our contractors involved, but if we need additional help either through the Nation's scientific community or some other agency or some other contractor, we can involve them on an individual basis.

We are starting first with the criticality 1 items and then the criticality 1R's, and then also we are going to extend this through the so-called criticality 2 items, and that is a category that where the loss of the item would not endanger the vehicle or the crew, but it would endanger the mission, and in that particular category we are making sure that they are not miscategorized, and that they really should be a safety problem rather than a mission problem.

It is well under way. I project that there will be some hardware changes recommended, and in addition solid rocket joints that we know that we must redesign.

Senator RIEGLE. Might I just ask, in that category of other possible redesigns other than the rockets, do these appear to be major items, or relatively minor items? Are we talking about substantial redesign jobs?

Admiral **Truly**. To me they are major, because if you are going to lose a vehicle or the crew, even if it is an O-ring, or a glass, it is major. In a schedule sense, the things that are being discussed I believe that I know about, and there are going to be some hard decisions that have to be made here because even when all the data is in, you end up in a complex technical situation with various camps, one that would say it must be fixed, one that would say you should not fix it, you should do something else, but it looks to me like in a schedule sense that other items we would approve will fall within what I believe to be about the 18-month downtime of the solid rocket motor, but it is possible that I am wrong, and if we find an item that has to extend to fly again, I am going to insist that we fix it.

Senator **Riegle**. Good for you.

Senator **Gorton**. Senator Gore?

Senator **Gore**. Thank you, Mr. Chairman.

Mr. Mahon, you mentioned earlier when I asked you about the quality control on the SRB that in addition to the work done at Goddard you relied on DOD quality assurance people out at the Thiokol plant, correct?

Mr. **Mahon**. Yes, sir. I do not know whether you are familiar with it or not, but when NASA started, rather than duplicate the inspection services that the military had started since many of the contracts were in the same plants, they made an agreement to use what we call the DCAS, Defense Contract Administration Services, and they do the inspection services or ensure that the inspection services are made.

[The following information was subsequently received for the record:]

The referred O-ring inspections that were "deleted" by NASA/AFPRO were, in fact, left out of the planning paper for STS 51-L by oversite. A review of the inspection records of the secondary O-ring associated with the right-hand aft field joint of STS 51-L indicated three critical U.S. Air Force mandatory inspections, required to accept this hardware for flight, were omitted from the inspection planning. These three inspections were: (1) Inspect to assure that voids and discontinuities are within specifications. (2) Inspect to assure that O-ring scarf joint mismatch is within specifications. (3) Inspect to assure that no more than five scarf joints are present.

Corrective actions by both NASA and USAFPRO have been instituted to prevent future inspection oversites in the flight hardware inspection points.

Senator **Gore**. I understand. Now, isn't it true that certain critical inspections of the SRB that were performed by the DOD personnel were terminated by Thiokol without approval from NASA's project office?

Mr. **Mahon**. Sir, first I would like to define my responsibility. I have all of the expendable launch vehicles. I have not any responsibility for the Thiokol SRB's.

Senator **Gore**. Do you know the answer to the question?

Mr. **Mahon**. No, sir, I do not.

Senator Gore. Do you, Admiral Truly?

Admiral **Truly**. It is my understanding that in the Rogers Commission investigation, there was an instance where an inspection or inspections, and I am not personally familiar with it, but it is on the public record, and I can get the information to you, was omitted on the paperwork. I do not recall that it was a case of where the contractor intentionally removed it, and it was not in this instance, as I recall. It was dropped, should not have been dropped, and in the paper search in the investigation we discovered that.

If that is the instance, I will be glad to research it more and get you the information.

[The following information was subsequently received for the record:]

In mid-February 1986, during a review by NASA/MSFC of Morton Thiokol records, conducted in support of the Challenger accident investigation, it was discovered that three Government Mandatory Inspections (GMI's) had been improperly omitted from the SRM Case O-ring receiving inspection planning.

An investigation conducted by Morton Thiokol quality engineering, at the request of NASA/MSFC, revealed the omission was the result of errors made during revision of the o-ring receiving inspection planning. The planning had been revised in late September 1984, in response to revision of the o-ring drawing and specification which had been completed about two weeks earlier. The drawing and specification were revised to eliminate some duplication of criteria by deleting nine notes from the drawing and placing the criteria, from those notes, in the specification. Due to a quality engineer's error the revised planning was not fully responsive to the drawing and specification revisions.

The inspection points relative to the drawing notes were deleted from the planning, but only part of the note(s) criteria transferred to the specification had been included in the revised planning. The error was in the quality engineer's rationale, that the specification was an ancillary document. As such, the criteria it continued should not be applied in the receiving inspection planning. Engineering intended the specification complement the drawing, as an equal in requirements hierarchy.

Although the quality engineer was unsure regarding the effected GMI's, the same rationale was applied. Thus, the three GMI's which had addressed a portion of the transferred criteria were omitted. The quality engineering system for handling and controlling the GMI was found to have been used successfully, numerous times, by other quality engineers, before and since this error occurred.

For the record, the investigation also revealed the GMI omission had been noticed at least twice prior to the February 1986 discovery. However, due to peculiar circumstances neither of those earlier notices provoked action to correct the error. The quality engineer's rationale for not including all of the specification criteria and the three GMI's in the revised inspection planning indicates inadequate training or failure to respond satisfactorily to training provided. The quality engineer did not seek supervisory assistance when insecurity regarding the GMI was encountered, which is contrary to provisions of the Morton Thiokol employees code of conduct.

Although the quality engineering system for handling and controlling the GMI can be considered functional, this occurrence indicates additional strengthening is necessary. The corrective actions taken included reinstating the three GMI's on March 21, 1986. Also, disciplinary action, as appropriate, was taken with the quality engineer. Additional training from all Morton Thiokol quality engineers on the GMI system and in formulating the inspection was completed in April 1986. In addition, a review of all active SRM planning to detect any other problems with GMI has been initiated with a completion date of the end of July 1986.

The Air Force has also added a planning review check point to assure all GMI's are incorporated in the Morton Thiokol planning paper.

Senator GORE. I appreciate it, and I wish you would provide that for the record. It is my understanding that inspections by the quality assurance personnel of DOD that NASA was relying on were discontinued by Thiokol without NASA approving it or perhaps even knowing about it. Also, it is my understanding that the DOD quality assurance personnel have responsibility for a whole variety of DOD projects there, including the HARM and the STANDARD missles and perhaps other work, and that NASA's work is just an extra part of their responsibilities, and that to me is another reason why NASA should once again do that work itself.

Now, I am informed that even the inspector general at NASA has now lost the ability to do audits on his own, and has to contract out with the Department of Defense to get IG audits done. Is that correct?

Admiral **Truly**. I do not know the answer to your question, sir, but I will certainly provide it for you.

Senator **Gore**. OK. Well, if you were not so new in your job I would say that the head of the space flight program ought to know the answer to that question, but you are new.

Admiral **Truly**. I cannot disagree with that at all.

Senator **Gore**. Now, in the immediate aftermath of the *Challenger* tragedy, there was a press conference by NASA with, I believe, several centers involved, and in reviewing the transcript of that press conference, it is difficult to determine from my copy of it which NASA official made this statement. But there was a question specifically about rumors of reductions in quality control, and the answer given by the panel, and Mr. Mulloy was the head of the panel, I cannot confirm that he made the statement. Perhaps others will be able to, but the response given was, and I quote, "In fact, we have a larger total percentage of our civil servants involved in Q&RA activities today than we did in our peak employment year."

Now, Q&RA is NASA's designation for quality control, and Q&RA is the designation on the figures that I provided to you earlier. It would seem to me, just on making a cursory examination of that statement, that it was wildly inaccurate. Would you agree? I guess you might want to review the figures.

Admiral **Truly**. I would not agree or disagree, sir. I think that would fall into my commitment to you earlier, and I will get an agency response to your question.

Senator **Gore**. I think it is not only inaccurate. It might not be unfair to characterize that response as misleading. In fact, the overall reduction in NASA personnel since the peak year has been about 31 percent, and the reduction in Q&RA personnel or quality control personnel has been, as I noted earlier, 71 percent.

Now, your chief engineer, about whom you have heard earlier, Dr. Silveira, was quoted in one of the morning papers this morning, the Post, as saying that engineers there had recommended an increase in quality control personnel. Are you aware of that?

Admiral **Truly**. Not other than having read the article in the Post.

Senator **Gore**. He was quoted in the New York Times as acknowledging that there may be quality control activities that "we are just not doing any more." Could you provide a list to the subcommittee of those quality control activities that NASA is just not doing any more?

Admiral **Truly**. I will have him do it. It is his responsibility, and I will have him do it.

[The following information was subsequently received for the record:]

Centralized training and certification of NASA, Government agencies and contractor personnel in workmanship standards like soldering and in reliability and quality assurance requirements.

In-depth R&QA surveys (audits) of our contractors, especially our subcontractors, and suppliers.

Annual R&QA surveys (audits) of our NASA centers. Now biennial surveys are being conducted.

Full-time active participation in program reviews by Headquarters R&QA personnel.

In-depth review of FMEA/CIL by Headquarters R&QA personnel.

In-line review of electronic parts application.

Regular/periodic visits to NASA centers, contractors and subcontractors to discuss R&QA problems.

Establish/assign a single point of contact for SR&QA within the Office of the Chief Engineer for each program or program element.

Decreased assignments of R&QA personnel (engineers) to monitor contractors.

Active Headquarters participation in project R&QA meetings at the centers and contractors.

Regular visits to contractors and subcontractors to certify training programs.

List of "quality activities we are not doing anymore" but transfer to other organizations.

Metrology/calibration at certain centers.

Testing of parts, assemblies and systems.

Non destructive evaluation development.

Electronic parts.

Environmental testing.

Material testing.

Inspection and verifiction at contractors.

Senator Gore. I would like you to be familiar with that list, too, Admiral Truly. Now, the policy questions that were pursued earlier are also of great concern to me, and particularly the fact that as Senator Riegle noted, we on this subcommittee are being asked to make extremely difficult, complex decisions, and we do not have any recommendation from the administration.

Am I correct in hearing your earlier responses to mean that you do not have a recommendation as to whether we should build another orbiter or not? Should we build another orbiter?

Admiral Truly. No, sir, that is incorrect. We recommend strongly that we build a replacement orbiter. That decision along with the decision as to whether or not the administration should forward a supplemental this year is the very issue that is being worked within the interagency group. I have never been to one of their meetings, and I am not a part of that process. As soon as the President makes the decision on the supplemental and the replacement orbiter, NASA intends to immediately comply with that decision.

Senator Gore. Well, as I understand the official position of NASA at this point, it is that you are recommending that we build another orbiter, but you are not recommending that we appropriate any money to pay for it. Has OMB cleared the SIG space, the SIG recommendation for money for another orbiter?

Admiral Truly. One of the major issues that I know is being discussed within that group is how we nationally would fund the total bill of the replacement orbiter and the DOD's recommendation for increased CELV production, and the supplemental to allow us to not damage our programs as we recover from the Challenger accident.

The decision will be the President's as to how he recommends that to the Congress, that we fund those items, and I am not privy to where that stands within the group.

Senator Gore. Well, my understanding is that the senior group that has responsibility for policy in this area has recommended that a supplemental be requested, and that funds a new orbiter, but that the Office of Management and Budget has said to them, no, you cannot make that recommendation. You have to find offsetting cuts elsewhere in the budget rather than asking for a new appropriation, and that as a result, in this period of absolute crisis in

America's space program, when the country is looking for direction, and the Congress is trying to make complex decisions, the administration is paralyzed, providing a vacuum of leadership, no guidance, no formal recommendation, and no budget request.

Now, if you have information that OMB has not done that, I would like to hear it, but that is my understanding of exactly where the situation stands and exactly why we have no budget request.

Admiral TRULY. I will be as honest with you as I can. I am not privy as to how it stands within the interagency group. I know that there have been major discussions between the various agencies as to how to fund the request. I know of no recommendation for NASA to take the cost of a total orbiter out of our direct budget in total. I just do not know what recommendations are being taken to the President nor where the process stands.

Senator GORE. Well, it is in a state of limbo, and my time has expired, but it is in a state of limbo, and the agency which has been drifting is now drifting even more. With new leadership and with your participation as well, now is the time to get moving in the right direction again, but the administration, the President, and Mr. Regan have to give the go-ahead and say to OMB, come on, let us get this straightened out.

One final short comment, and I do not wish the heat of my remarks to be directed at you personally, Admiral Truly. I wish to close by reiterating again my deep wish that you have a good, enjoyable, effective tenure there. I am frustrated with the administration on this particular question, and with the past leadership at NASA for the debacle in quality control that I referred to earlier.

Thank you, Mr. Chairman.

Senator GORTON. The Chairman has already indicated that he shares that frustration of the inability to get a recommendation from the administration.

Senator Hollings.

Senator HOLLINGS. Thank you, Mr. Chairman.

Admiral Truly, let me see if you can change step and go back to the particular concern that I was asking about with respect to quality control. I think back when years ago my kids listened to a little radio program, Big John and Spark, and they had a little limerick all the way through, "In life, make this your goal, keep your eye on the donut and not the hole." With respect to quality control, we know on January 28 that it was not quality control that was the proximate cause of this disaster.

We in the law think in terms of proximate cause. If we had a trial court here we would knock all the questions out about quality control for the simple reason that the particular defect was foreseen and warned against. That is why I have not asked all the questions. I am as interested as the distinguished Senator from Tennessee about quality control, and I am sure you are, but that is not the measure as to whether you had 10 or 20 or 300 years ago you had 1,000 and now you have only 5.

On January 28, we had a design defect that was warned against, and we launched over the objection of two contractors, and we will have to go and wait until the Rogers Commission report is filed, and then we will get into that. But prior to getting into that, we are back down to the design defect that we have struggled with over quite a period of time and could not solve, and now let me get to the proposition, and trying to flex your mind about contractors.

Senator **GORE**. Would the Senator yield?

Senator **HOLLINGS**. No, I want to complete a thought. I have a hard time getting this mike away from you.

I mean, he was he is pretty good over on the House side, but we are going to have to get a little exercise, too, over on this side to catch up with him and, Senator Gorton, you do not have much longer to hold the chairmanship. He is going to be over in that seat before long.

Senator **GORTON**. That is news to Senator Riegle.

Senator **HOLLINGS**. Now, going right to the point of contracting and getting those to participate, can you imagine to my shock some 4 years ago a textile industry left South Carolina and went to Michigan? Can you imagine that? J.P. Stevens. You know, we have got a right to work state, and we are going up to a labor state and all that kind of stuff. Now, why did they do that? They do that on account of competition, modernization, and robotization.

The automobile industry in Flint, MI, demands that they have a 4-hour delivery of automobile upholstery, and in order to comply with that demand, no one can ship it from Greenville, SC, up to Flint in 4 hours, and so in order to comply, in order to compete, they took the contractor, the requirements of the contractor, and said, look, we will have to build a plant up there in Flint, MI.

Senator **RIEGLE**. My home town.

Senator **HOLLINGS**. So they just punched a computer and that plant goes right from their plant right into the auto textile plant and it is put on a truck and delivered. You in NASA have got to flex your mind. Man, this thing is moving. And with respect to a contractor on the solid rocket booster, let us get rid of the segmented boosters. Give it the proper designation. You have not had a solid rocket, and that is our problem. I do not mind Morton Thiokol. I am not against or for any contractor, but I would like a "solid" solid rocket boosters. Let's tell Morton Thiokol and United Technologies and Aerojet and Hercules and all the folks that want to compete, the prime requirement now since the *Challenger* disaster is a reliable solid rocket booster with no field joints.

We are going to have a proof positive solution to the O-ring problem, so our astronauts will not have a worry in the world about the joints going apart any more. If you need a barge to transport these monolithic boosters, I have got Church Creek at Charleston full of barges.

You know the Sixth Naval District. We have got them all mothballed up there. So do not worry about barges and all those things that seem to get in your mind. You folks have got to flex your minds and get moving and solve that problem immediately, and quit running around. The answer is obvious. You can get a "solid" solid rocket booster and build one at the site and get a barge from me, and we will move it on around wherever you need it, so that is that.

Now, with respect to the budget, Mr. Steel, I go over to the Congressional Budget Office and I asked, along with the distinguished chairman here, the budget effects of the *Challenger* accident. I get that from CBO, but I do not get it from you. You seem to be giving information to the Rogers Commission and to what they call the SIG, Senior Interagency Group. NASA has got all kinds of studies, but the folks that make the decision, we get nothing. We get a sheet of paper here that says $7.694 billion. They have accident impact minus 497, and then say add-ons plus 497, so they still ask for $7.694 billion.

But we know that these numbers reflect the down time of 12 months and realistically it is nearly 18 months so it is wrong there. It projects 18 missions. Well, we are going to be nearer 12 to 14 missions. Why play around? Why do you not give us the information? That is all we are asking for. We have got to make intelligent decisions, and I do not have a budget from you. Everybody else seems to be getting one. I have to read it in *Aviation Week* or the *New York Times*.

But I cannot get the impact and find out all about the space station and find out all about the cost and everything else like that, and you are just moving all around between 12 and 18 months. Just give us the document that you are relying on. Give it to the subcommittee so we can all be talking the same vocabulary and the same figures. Mr. Steel, why not? Can you get that to us?

Mr. STEEL. Sir, as we mentioned earlier we do not have estimates for an 18-month downtime. The reason you have a summary that is based on 12 months is immediately following the accident there were discussions of various options. It was determined at that time to preliminarily baseline 12 months down, to go out to the NASA centers to identify the savings and more importantly to implement those actions that were necessary to achieve the reductions that went with 12 months.

Senator HOLLINGS. You say in your statement once we return to flight status, our priorities for flight payloads include critical national security requirements, and you go right on down. We have established a planning baseline of 12 months standdown with a contingency planning schedule which assumes an 18-month standdown, you see, rather than the either/or, just whatever realistically you really think are the outside limits, so you get enough money.

I do not think this committee wants to deny you any money. I do not know that you really cut corners due to a lack of money. There is evidence galore to the effect that there were all kinds of waste, fraud and abuse in NASA just like it is in the Pentagon.

There are articles that we are going to have to review concerning your bidding and your sole source contracting. We have to almost take the Packard Commission and tell them to run on over to NASA now and do the same study for us because there has been a lot of waste over there. Maybe there is not, but there appears to be.

Let us get a budget document up here that a Senator can intelligently study and try to make the best guess we can. Right now, we get nothing. We are the ones who are responsible, not the SIG Committee. They are not going to appropriate anything. NASA is not going to appropriate to themselves, nor is the Rogers Commission. It is going to be gone this time next month.

It seems like you could give us a document.

Admiral TRULY. Senator, we have been working as hard as we can internally in the Office of Space Flight to provide a recommendation to the Administrator which I discussed earlier about a new flight date and a reasonable and safe sustainable flight rate that we can project into the future.

I have done that, but I did not do it external to the agency. It was not until last Friday that I had the data to make my recommendation.

Senator HOLLINGS. Can you have it in the next week for us?

Admiral TRULY. That recommendation has now been briefed to Dr. Fletcher, and it is tops on his priority list to determine that. When that is determined, it will allow us to immediately revise our budget estimates. There is no higher priority in the agency than to do that.

Senator HOLLINGS. All right. One final question with my time.

Relative to the criticality 1 studies, the Rogers Commission has recommended an independent watchdog group or independent group to make that study. You are making it with the contractors. That is rather incestuous, particularly now with the general public concern. Why not get an independent group to line it all out for you.

I happen to believe, as your answers indicate, that the entire program has got to be quality controlled and not just measured by the number of inspector generals and what have you. I mean, everybody has got to be quality conscious in every move they make in the Space Program. I think that has proved out. You have a successful program.

If you look at the design on that particular chart there, it is a wonder that you did not all wreck on the way to Cape Canaveral. Nothing would have happened. On the contrary, everything has happened right up until this year. Why not an independent group rather than the contractors studying with NASA and NASA studying with the contractors?

Admiral TRULY. I have talked with Chairman Rogers, Dr. Graham, and Dr. Fletcher on this specific point a number of times. It is my understanding that the independent and senior group which the Commission recommends, and frankly which I absolutely concur with him in, is a group that would specifically have oversight primarily over the solid rocket motor redesign, recertification and retest effort, since that was the cause of the accident.

It is true that the Commission has not completed its work, and they may have a further recommendation the critical items list review. I would propose that a more reasonable and effective way to do that would be to have an independent group review not the entire 1,000 critical items but those that are controversial.

Those on which I or the Administrator have to make a decision to either change the hardware or not I would propose that a senior and independent group have access to that as we go on. I think that all of us, the Commission, the Administrator, and myself, see the need for that.

Senator HOLLINGS. You are going to do it?

Admiral TRULY. We are going to do it. It has not yet been done, frankly, because of the timing. The Administrator had not been confirmed, and since he had not had an opportunity to discuss it with the Commission or internally even with me, it is not in place yet but it is going to be done very, very quickly.

I would propose that this group remain with us, not just for the design which will be decided on fairly early, but all the way into flight just to make sure that we are going to keep our word on being as safe as I say we are going to be.

Senator HOLLINGS. Thank you. Thank you, Mr. Chairman.

Senator GORTON. Admiral Truly, we really put you through your paces today. You already have an additional assignment, of course, in answering other questions. Some more will be submitted to you in writing.

Senator GORTON. We do appreciate your coming here today, and we appreciate the work that you are doing to get NASA back on track.

Admiral TRULY. Thank you, Mr. Chairman.

[The statement and questions and answers follow:]

Statement of

Richard H. Truly
Associate Administrator
Office of Space Flight

National Aeronautics and Space Administration

Mr. Chairman and Distinguished Members of the Subcommittee:

It is my pleasure to accept your invitation to testify before this Subcommittee. I am here today to present the Office of Space Flight's FY 1987 Budget request which was transmitted to the Congress on February 5, 1986, and to discuss revisions which will be necessary -- to the extent that we have been able to identify them -- as a result of the Challenger accident on January 28. The loss of the Challenger affects several OSF programs and will change the request pending before you. Although a detailed and very specific assessment of all the impacts of the accident upon our programs will not be completed until later this month we can specify the various impacts in general terms. These impacts may change as a result of the accident investigation, but at a minimum include the loss of an Orbiter and associated onboard hardware, the need for a complete review of all procedures and hardware systems affecting flight safety, implementation of necessary system modifications, and a flight hiatus of at least a year.

Mr. Chairman, before discussing the impact of the stand-down, it is important to review briefly some of last year's accomplishments. During calendar year 1985, the eight Space Shuttle missions achieved numerous technological, scientific, and commercial milestones. These included the retrieval and repair of the Syncom IV-3 spacecraft, the EASE-ACCESS demonstration of space construction which will be invaluable in developing plans for the Space Station, the flight of two Spacelab missions including the first reimbursable Spacelab mission, the first two dedicated Department of Defense missions, and five commercial Shuttle satellite missions. Several major scientific experiments, such as the Continuous Flow Electrophoresis System (CFES) and Physical Vapor Transport of Organic Solids (PVTOS), were also carried out. These experiments promise new or previously unobtainable quantities of materials and pharmaceuticals for medical and scientific uses. All of these accomplishments will provide an extremely useful base of experience when we return to flight.

With the loss of Challenger, we have lost one quarter of our Shuttle fleet and are currently in a stand-down mode. For at least the next three and one-half years, we will be limited to a three-Orbiter fleet, and there will be a slower buildup in flight rate than had been planned before the accident. A three-Orbiter Shuttle fleet and the associated infrastructure is estimated to have a sustainable flight capability of 12 to 18 flights per year. If an Orbiter had to be removed from the flight schedule for an extended period of time, and the Nation could only utilize a two-Orbiter fleet, the maximum flight rate would not be greater than ten to twelve flights per year. When the three-Orbiter Shuttle fleet resumes flights, there will be a significant flight capacity shortfall with the backlog of payloads to be flown and lost flight opportunities.

Although production capability for a replacement Orbiter varies depending upon the specific contractor, the normal build time of an Orbiter, based on OV-103/OV-104 experience, is about 5 years. As a result of the structural spares program, many of the long-lead items, such as the aft fuselage and crew module, are nearly complete and an additional Orbiter could be available for flight in three and one-half to four years, after we have the authority to proceed.

Our major energies are currently absorbed in the analysis and implications of the STS 51-L accident in support of the Presidential Commission. We are critically reviewing and evaluating all aspects of the program including a formal reevaluation of the STS program Failure Modes and Effects Analysis (FMEA) and the Critical Items List (CIL) as well as a reassessment of program management structure. While these activities are our most important function at this time, it is equally important that the program move ahead with corrective actions in the areas where design changes are required. I believe that the cause of the failure of STS 51-L will be identified and fixed, and we are proceeding on that course. The entire effort to investigate the accident, to conduct salvage operations, to support the Presidential Commission, to reassess our program capability and to correct those items which must be corrected, will be examined in the Administration's budget process.

The loss of Challenger reduced the compatibility with the Centaur upper stage to one Orbiter. Accordingly, we have initiated procurement of the equipment necessary to modify Discovery for Centaur compatibility to restore the two orbiter capability needed to support flight requirements. At the same time, we will examine funding requirements for design, development, test and evaluation (DDT&E), for completing an analysis of safety waivers and incorporating safety enhancements to the Centaur design, and for delays in the Galileo and Ulysses launches.

The pending budget authority requested for the Space Transportation System (STS) Program in FY 1987 is $2735.6 million. Space Flight Control and Data Communications (SFCDC) totals $2270.1, and Research and Development (R&D) totals $465.5 of this amount. Activities included in SFCDC are Shuttle Production and Operational Capability and Shuttle Operations. The Research and Development appropriation for the Space Transportation Capability Development Program provides funds for Spacelab, Upper Stages, Engineering and Technical Base, Payload Operations and Support Equipment, Advanced Programs, Tethered Satellite System, and the Orbital Maneuvering Vehicle. I anticipate that funding in these areas will have to be significantly increased to support to recovery activities associated with STS 51-L. To the maximum extent possible we will offset these requirements through the associated changes to Shuttle Operations and Research and Development.

The objectives of the Shuttle Production and Operational Capability budget include funding for Orbiter capability enhancements and modifications, establishing a logistics system including an initial spares inventory and structural spares; for production readiness, producibility, and capability development of the propulsion systems including a significant Space Shuttle main engine (SSME) development effort to improve operating margins and life limits; for mission preparation, mission control, and launch site capabilities; and for the potential changes and upgrading of the STS. This category, for example, includes on-going Orbiter improvements such as the general purpose computer (GPC), auxiliary power unit (APU), inertial measurement unit (IMU), carbon brakes, and nose wheel steering which were initiated prior to the STS 51-L accident. To support the activities in this category, we have requested $745.4 million in FY 1987.

I anticipate that funding in some areas will have to be changed to support recovery activities associated with STS 51-L and we will offset these requirements to the maximum extent possible.

Shuttle Operations direct appropriated funds are combined with reimbursements received from other U.S. Government, commercial, and international customers to support the flight activities including procurement and refurbishment of flight hardware, launch and flight operations. For FY 1987, $1524.7 million of direct appropriated funds is requested. These estimates were based on supporting 17 flights in FY 1987 and 18 flights in FY 1988 and will need to be revised to reflect changes from the planned flight rate and the loss of planned offsetting reimbursements.

The budget request for Research and Development for the Office of Space Flight totals $465.5 million in FY 1987. This includes funds for Upper Stages, Engineering and Technical Base, Spacelab, Payload Operations and Support Equipment, Advanced Programs, Tethered Satellite System, and the Orbital Maneuvering Vehicle. We are reviewing a number of activities in this area critically and plan to implement adjustments in those areas affected by the reduction in near term flight activity.

My primary goal for the Office of Space Flight is that we return to a viable and safe program with a safe and sustainable Shuttle flight schedule. We have established a planning baseline of 12 months stand-down, with a contingency planning schedule which assumes an 18 month stand-down. Once we return to flight status our priorities for flight payloads includes critical national security requirements; major science payloads such as the Hubble Space Telescope or payloads with specific launch windows, such as Galileo; other NASA/Government payloads; and commercial and foreign payloads. The actual downtime and flight rate buildup will obviously depend upon the specific changes that result from the thorough review of the program that is currently under way and the recommendations of the Presidential Commission. Our return to operations will naturally be a careful one, but we intend to make full use of the Space Shuttle as the U.S. Government's primary space launch capability.

The Administration, through the interagency process, is considering a broad range of options including expanded use of Expendable Launch Vehicles (ELV's). It is premature to comment on their recommendations at this time. As there will certainly be a shortfall in the U.S. space launch capabilities in the near term, we are looking at every possible way to minimize the impact.

Mr. Chairman, this is the end of my prepared testimony. I appreciate this opportunity to appear before you today, and would be pleased to answer any questions you may have.

QUESTIONS OF SENATOR GORTON AND THE ANSWERS

DELTA ACCIDENT

Question 1: It is my understanding that the SDI Organization, and not Transpace Carriers, has the rights to the three partially-built Deltas.

How will the Delta accident affect the disposition of these three Deltas?

Answer 1: SDIO has rights to Delta residual hardware per the NASA/SDIO Agreement signed November 24, 1985. The NASA/TCI Agreement was revised to reflect Government rights of first access to this hardware in Amendment No. 5 signed December 5, 1985. The recent Delta accident could affect disposition of this hardware, but that is unclear at this time.

Question 2: With the accident of the Titan and Delta ELV's, do you believe that we should re-think our national policy to privatize ELV systems -- is this an activity that should be managed by the government due to its inherent risks and dangers?

Answer 2: In privatizing ELV systems, we need to keep in mind that all space launches involve risk. Our manufacturers of ELV's have extensive experience in building and launching these vehicle systems with excellent success. We still believe that a privatized ELV system is a supportable goal.

Question 3: What is your personal opinion of the role that ELVs should play in NASA's Space Transportation System -- do you believe that NASA should manage a "complementary" system, such as DOD has decided to do, or should NASA payloads and missions rely solely on the Shuttle?

Answer 3: I think it is clear that an ELV capability would be a valuable complement to the STS. The DOD complimentary ELV (CELV) program is intended to fullfil this need. Since the Challenger accident, we have been exploring a variety of ways to utilize our available ELV capability. As part of this approach, I believe NASA should continue its efforts to commercialize its ELV's.

Shuttle Capability

Question 4: In its January 1986 report, NASA's Aerospace Safety Advisory Panel said that NASA's launch rate predictions are very optimistic and for the next two to three years 12 to 15 flights per year appear to be a difficult but attainable goal. I might add that this report predated the Challenger accident and was predicated on a four-orbiter fleet.

In light of this Panel's recommendation, do you believe that your projected flight rate of 12 to 18 launches per year is, itself, overly optimistic?

Answer 4: We are currently reviewing our projected flight rate after the Challenger accident. While we plan to fly at a lower rate during the first two years of operation after flights are resumed, it appears that with a 3 orbiter fleet, we will be able to achieve a flight rate of 12 to 15 flights per year in the third year of operation. With the replacement of the fourth orbiter, it would be possible to fly 4 to 5 flights more per year assuming adequate logistics and other support.

Question 5: With a three-orbiter fleet and a sustained flight rate of 12 to 18 launches per year, how long is it likely to take to work-off the backlog of payloads that is growing, given a downtime of 18 months?

How would the introduction of a fourth orbiter into the fleet alleviate the backlog problem?

Answer 5: As part of the recovery plan, the DOD is planning to offload a number of STS payloads to ELV's. Even with this, there will still be a considerable backlog by the end of 1992, based on an 18 month downtime. It is anticipated that with a three orbiter fleet this backlog will be over 50 shuttle equivalent flights. This backlog will never be worked-off on shuttle due to the lower projected flight rate after 1992 than was planned prior to 51-L and Space Station requirements. The backlog of communication satellites and a small percentage of the NASA payloads could be supported with ELV options, if they are made available or NASA payloads could be deferred or postponed, thus reducing the backlog requirements.

A fourth orbiter would reduce the backlog requirements by about 10 equivalent shuttle flights thru 1992. Beyond 1992, its availability would minimize any additions to the backlog.

Question 6: Secretary Aldridge testified before this Subcommittee that he expects the DOD to use approximately 4 to 6 Shuttle-equivalent flights per year.

Under what circumstances would you expect this DOD use to increase beyond 4 to 6 per year?

Answer 6: If the DOD were not able to obtain their additional ELVs we would expect their use to increase beyond 4-6 per year. Additional Shuttle use could also be triggered by a subsequent ELV problem that stands the ELV fleet down for a sustained period of time. The SDI Program may require additional usage of the Shuttle after 1992.

Question 7: Prior to the Challenger accident, NOAA had agreed to launch, beginning in 1991, its NOAA K, L, and M satellites aboard the Shuttle rather than on refurbished Titan II rockets.

In light of the Challenger accident, is this launch decision still valid?

Answer 7: The GOES series, scheduled for launch in the time frame of the question, are the I, J, and K satellites. These geostationary orbit satellites are larger than the previous Delta GOES and could go on either Shuttle or Atlas/Centaur. Our current projections indicate that the GOES I can be launched on Shuttle within 1 year from the 1989 requested launch date.

We also project that the polar orbit NOAA K, L and M satellites can still be supported on Shuttle from Vandenberg AFB.

Solid Rocket Motor Redesign

Question 8: I understand that NASA has established a Solid Rocket Motor Design Team to generate new designs and to flight-qualify a new solid rocket motor.

Could you describe the nature of this team and its mission--how much will it cost and how long will it take to develop an alternate design and to flight-qualify it?

Answer 8: A Solid Rocket Motor Design Team has been established to recommend and to overview the implementation of a plan to re-qualify the SRM's for flight. The team will generate design concepts, analyze, designs, plan test programs and analyze results necessary to certify flight readiness. This activity will be coordinated through the MSFC Solid Rocket Booster Project Office with Morton-Thiokol Inc. Alternative design concepts are currently being examined. Once a design approach has been selected, we will be able to solidify program and funding requirements.

Experts from MSFC and other Centers, and aerospace contractors are on the team. First flight of re-qualified SRM's is targeted to take place in July 1987.

Question 9: How dramatic a departure from the current solid rocket motor design are you willing to accept as a redesign--what limits are there in this redesign effort?

Answer 9: The SRM design team has not established any limits as far as changes in the current motor design certification. The team is looking at various options with the prime requirement to design a SRB joint which will be reliable for manned flight.

Question 10: What consideration is being given to terminating the reuse of solid rocket boosters, and if the reuse were terminated, what would be the budget implications?

Answer 10: We still plan on reusing the Solid Rocket Boosters (SRB's). All major structures such as the Solid Rocket Motor cases, aft skirts, frustums and forward skirts are designed for 20 uses.

The SRB systems are also designed for 20 uses with the exception of the parachutes which we currently plan to use 10 times.

Post flight assessment of returned hardware provides confidence that our reuse design criteria is still valid.

Solid Rocket Motor Second Source

Question 11: Generally, what has been industry's response to the January letter from NASA regarding a possible competition for a

Solid Rocket Motor second source?

Answer 11: The industry appears to be interested, although concerned, about our conditions and plans and their ability to recover their initial investment. Questions that the contractors submitted to NASA reflect this concern. We have placed on hold any responses to their questions and concerns until we have assessed the impact of the Challenger accident on our second source initiative.

Question 12: When will NASA decide whether or not it initiates a competition for a second source, and what factors will influence this decision?

Answer 12: NASA is currently reassessing the overall second source initiative in light of STS 51-L impact. Factors influencing our decision include:

- o SRM design change and qualification schedule.
- o New flight schedules and launch rates and hardware requirements.
- o Budget availability.
- o Introduction of required and desired changes (e.g., non-asbestos insulation).

Question 13: If a second source is awarded, will that company have to use the design decided upon by the Solid Rocket Motor Design Team?

How long will it take to qualify a second source, and when would it be flight-ready?

Answer 13: Our current planning is that any second source award would be based on whatever design is qualified/certified for flight. Based on data provided by the four contractors for our second source assessment it is our estimate that it would take 3-5 years for qualification for flight (depending on the contractor) from contract go-ahead.

Solid Rocket Booster Filament Wound Case

Question 14: How likely is it that the redesign of the Solid Rocket Motor Design Team will alter or invalidate the Filament Wound Case design?

Answer 14: Changes in the Filament Wound Case will probably be necessary. At this time we are uncertain of the extent of the changes that will be necessary and whether the changes will be confined to the metal rings only. Qualification tests would be necessary for whatever changes are required.

Question 15: In its January 1985 report, NASA's Aerospace Safety Advisory Panel has expressed concern about the testing regimen and the structural integrity of the Filament Wound Case.

Do you believe that the test regimen for the Filament Wound Case is thorough and adequate and that the structural integrity of the composite case is sound?

Answer 15: We are aware of the NASA Aerospace Safety Advisory Panel concerns. NASA has the same concerns and is conducting extensive analyses for flight certification. Several planned program tests are about to be conducted which will also provide a better understanding of the structural margin of safety of the composite case. NASA will not certify the FWC for flight unless our tests and analysis indicate all requirements have been met and an adequate margin of safety exists.

In addition to our own internal analysis, NASA has a Technical Assessment Overview Group (TAOG) composed of outside experts in composite and structural analysis to provide an independent review of the analysis.

Question 16: Does DOD intend to use the Filament Wound Case on its first Vandenberg Launch?

Answer 16: Both DOD and NASA current planning has baselined the use of the Filament Wound Case Solid Rocket Motor on the first flight from Vandenberg.

Centaur Upper Stage/Launch of Galileo and Ulysses

Question 17: The fiscal year 1986 cost overrun of the Centaur upper stage program was $100 million, and now, I understand that NASA is estimating the fiscal year 1987 overrun to be approximately $130 million, with the possibility that it could be $160 million to $180 million.

Is this fiscal year 1987 estimate still correct, and if so, how much of this is attributable to the delay in the launch of Galileo and Ulysses?

How much of this overrun is attributable to post-Challenger enhancements and redesigns, and how much is attributable to problems that predated the Challenger accident?

Answer 17: The $160 to $180 million still represents our best estimate, although the total cost is highly dependent upon the length of the STS downtime and scope of safety modifications which are now under review.

Approximately $76 million of the $160 to $180 million total is directly attributable to delaying the Galileo and Ulysses launches 13 months and 26 months, respectively, based on the Agency's preliminary post STS 51-L baseline planning of a 12-month standdown. Post-Challenger added program reviews and safety enhancements are estimated at approximately $25-75 million, depending on the necessary actions resulting from the reviews. Problems that predate Challenger are responsible for approximately $28 million for GD/C contract overrun, hardware changes, and APA on DDT&E work to go and the hardware changes. We are examining the Shuttle Centaur Program and are deliberating about the effects of its cancellation.

Question 18: It is clear that options for the launch of Galileo and Ulysses are limited, but does it seem that with the Centaur program, any additional investment in that program will be "throwing good money after bad money"?

Answer 18: Galileo and Ulysses are only two of seven missions currently planned using Shuttle/Centaur.

NASA missions are Galileo, Ulysses and Magellan (formerly VRM), and DOD has four missions planned using Centaur G.

The current estimate to complete development of approximately $65 million over current budget is a good investment considering planetary programs and national defense needs.

It should be noted that when the Shuttle/Centaur development has been completed, this upper stage will be an excellent enhancement to the basic Shuttle capability. The Shuttle/Centaur can be made to fly safely in the Shuttle and we are in the process of implementing this.

At present, an alternative to the Shuttle/Centaur high performance does not exist. A decision to utilize an Expendable Launch Vehicle would delay these important payloads into the early 1990's timeframe. Development of a new upper stage would require 3 to 4 years. In addition, either of these alternative capabilities will have development, production and payload modification costs associated with them. We are examining the Shuttle Centaur Program and are deliberating about the effects of its cancellation.

Centaur Upper Stage/Launch of Galileo and Ulysses

Question 19: Last week, in the course of the Challenger accident investigation, it was revealed that "launch constraints" were waived prior to several Shuttle launches.

Are there any launch constraints that now exist for the Shuttle/Centaur?

What about "safety waivers" — have any been issued, and if so, for what reasons?

Are these safety waivers being reconsidered?

What will be the time and cost to remedy these safety waivers?

Answer 19: The launch constraints that exist at this time are the acceptable completion of systems tests, hardware enhancements, and reviews/analysis. There are also safety reviews yet to be held and data submitted, and safety waivers that must be approved prior to launch.

There are seven (7) flight safety waivers in the system at this time for the following reasons: lack of two failure tolerance, less than 2.5 safety factor and material application deviation.

Yes, all safety waivers are being reviewed to determine if modifications could be made to either retrofit or design in the necessary changes to the system to remove and/or minimize the safety waiver condition.

The cost to remove and/or minimize the safety waiver condition is included in the $30 million for enhancements and the estimated $30 to $50 million of additional APA that would bring the program total new requirement to $160 to $180 million. The identified work is scheduled to be completed in calendar year 1987. We are examining the Shuttle Centaur Program and are deliberating about the effects of its cancellation.

Centaur Upper Stage/Launch of Galileo and Ulysses

Question 20: Certain questions have been raised about the safety of the Centaur and its liquid propellant, particularly in the context of its use on the Galileo and Ulysses missions, which use radiosotope thermoelectric generators (RTGs).

Do you have any safety concerns about the use of the Centaur in combination with RTGs aboard a manned vehicle?

Do you believe that any risks associated with the Centaur on these two missions are now acceptable, and, under what circumstances would you be compelled to use a different upper stage?

Answer 20: The Shuttle/Centaur program has been in a replanning phase since the 51-L accident. As part of this process, the Centaur vehicle enhancements and indepth reviews are underway. With the successful completion of these reviews, incorporation of the hardware enhancements, along with the satisfactory completion of our normal safety review process, the Centaur vehicle will be safe to fly in the Shuttle.

The addition of RTG's does not increase the risk to either Shuttle or crew. The RTG's themselves are inert hardware that pose no hazard to the safety of flight for the crew or the Space Shuttle. The only way that the RTG's can become a hazard would be as a result of breeching their cases during a total catastrophic failure of the Shuttle system. However, we are taking every possible precaution to ensure that the cases can withstand a catastrophic failure.

Flying any upper stage in the Shuttle introduces risk. The degree of risk is the item in question. The degree of risk associated with the Centaur will be identified and its acceptability will be considered. Due to time constraint, the alternatives being considered today are expendable launch vehicles (ELV's) rather than other alternatives within the Space Shuttle. We are examining the Shuttle Centaur Program and are deliberating about the effects of its cancellation.

Question 21: I understand that some consideration is being given to launching the Galileo, Ulysses, and Magellan missions aboard Titan 34D7/Centaur vehicles.

Could you comment on this launch option and compare the costs of launching these spacecraft on the Titan to the costs of Shuttle launches?

Answer 21: We have conducted some preliminary examination of the Titan 34D7/Centaur as a suitable launch vehicle for these missions. The major problem is that the Shuttle/Centaur has been designed for delivery into orbit in the Shuttle payload bay, from which it is "pushed out". A different design would be required for the "lofting" trajectory of an ELV. How much this redesign effort would cost is not known at this time.

The launch cost would be considerably higher than the STS launch costs, depending on the ELV and upper stage costs, both of which are unknown at this time.

Another problem would be the availability of the Titan 34D7, considering the USAF priority requirements.

Centaur Upper Stage/Launch of Galileo and Ulysses

Question 22: To what extent would a Titan 34D7/Centaur launch alter the scope of these three missions, as currently planned?

Answer 22: A first look indicates that the currently planned scope for these missions would not be altered.

More detailed analysis will be required upon selection of the most appropriate vehicle available for this class of mission before a more definitive answer can be given.

Question 23: Under what circumstances would you launch any of these three planetary missions on an ELV?

Answer 23: If it was determined that an STS launch was not available before a Titan 34D7, along with its suitable upper stage, we would use the ELV. We are examining the Shuttle Centaur Program and are deliberating about the effects of its cancellation. We are, also, examining options to accomplish these missions.

Question 24: In its prepared testimony, NASA's Aerospace Safety Advisory Panel has raised the question of whether or not there should be an unmanned flight test of the Centaur.

What is your response to this question, and what would be the budgetary implications of conducting such an unmanned test flight?

Answer 24: We cannot fly an unmanned flight test of the Centaur vehicle system in a Shuttle. The only unmanned flight test would be on an expendable. From the start of the Shuttle/Centaur program, directions were that changes to the Centaur vehicle itself would be held to a minimum to accommodate manned safety requirements and increase propellant tankage capability. In essence, the basic Centaur vehicle is similar to the Centaurs that have flown over the last 20 years on both Atlas and Titan.

In addition, as part of the 51-L enhancements, a requirement for a dynamic flow capability has been added to the program to exercise all redundant paths and check system margins under dynamic flow conditions.

Question 25: The Aerospace Safety Advisory Panel has expressed concern about flight crew training, in particular, an adequately-sized fleet of Shuttle Training Aircraft and accurate ground simulators

Do you believe NASA's flight crew training program and facilities warrant additional consideration, particularly, in the areas mentioned by the Aerospace Safety Advisory Panel?

Answer 25: Yes. We are continually assessing crew training requirements and availability of training equipment and facilities.

The Shuttle Training Aircraft (STA) fleet will be capable of meeting the flight crew training needs over the next few years in view of the projected manifest for a 3-orbiter fleet. The need to purchase and modify an additional aircraft for availability in the FY 1988 timeframe is being evaluated.

We are also reviewing the requirements for Shuttle Mission Simulator upgrades in FY 1988. In addition, an automated validation software system is under development to check the accuracy of ascent/entry parameters for simulation application.

Question 26: I understand that with the loss of the Challenger, the Orbiter Discovery is being modified to accept Centaur payloads.

How much will these modifications cost? Should NASA consider delaying these modifications until the Shuttle/Centaur issue is finally resolved?

Answer 26: Prior to the accident two Orbiters were capable of Centaur missions. With the loss of challenger, no backup capability exists for Centaur missions. Modifying OV-103 will provide backup capability should it be required and allow schedule flexibility for Centaur launches.

The basic Orbiter/Centaur modifications for OV-103 are expected to cost approximately $5 million. Most of the $5 million has been costed and, therefore, minimal savings could be achieved if the modifications were stopped. The modifications are expected to be complete by September 1986.

Orbital Maneuvering Vehicle (OMV)

Question 27: When do you expect to select the design winner of the Orbital Maneuvering Vehicle (OMV) competition?

Answer 27 Under our current plan, the Source Evaluation Board has been constituted and is evaluating contractor proposals. The planned date for contractor selection is scheduled for June 1986.

Question 28: Space Telescope refurbishment and servicing has been identified as one of the first major OMV requirements. With a delay in the launch of the Space Telescope and the resultant delay in the servicing requirement of the OMV, should the OMV development be delayed, or are there other OMV requirements that will precede those of the Space Telescope?

If so, what are these requirements?

Answer 28: The Space Telescope is currently scheduled to be launched in late CY1987 or early CY1988. The servicing requirement is scheduled nominally for three (3) years after launch. However, depending on the solar activity during this time, this could vary by 6 months; i.e., 2 1/2 years years to 3 1/2 years or sometime in 1991. OMV is scheduled to be operational in the fourth quarter of CY1991. Even if there is a delay in the Space Telescope schedule, the OMV operational date should not be delayed by later than fourth quarter CY 1991.

Although there are a number of candidate missions, at this time there are no other firm requirements for the OMV. However, the OMV should be operational is sufficient lead time so that certification and demonstration can be accomplished on either a test article or another user other than Space Telescope.

The OMV schedule should not be impacted or delayed as a result of the backlog of STS flights. On the contrary, the OMV will be a valuable asset in helping to reduce the backlog of flights because of its versatility (spacecraft servicing, retrieval, reboost, viewing and delivery). With these capabilities, the OMV will prove invaluable in complementing the STS in reducing mission time and, thus reducing the backlog.

Space Shuttle Main Engines

Question 29: When does NASA intend to resume its tests of the Shuttle main engines, both single-engine tests and cluster tests of the three main engines?

In light of the Challenger accident, what are NASA's plans regarding tests and operations of the Shuttle main engines at 109% power level?

Answer 29: A two day review held at MSFC on April 24-25, 1986, "SSME Test Resumption Review," covered all issues/concerns needed to be resolved prior to the resumption of SSME testing. Those issues are closed out and single engine testing has resumed.

Cluster tests at 109% thrust are scheduled for January 1987, or later. This MPTA test is required prior to the first 109 percent flight which will be in the late 1989, early 1990 time period.

Testing at thrust levels above 104% is being reviewed for adequate safety margins due to the fuel pump blade problem.

At the time of the accident we were not ready to fly at 109%. However, tests including MPTA, were scheduled to certify the SSME for 109 percent flight.

The delay in the flight schedule, brought on because of the accident, will allow additional laboratory tests and analyses to resolve problems and to allow testing to resume at the 109% power level this summer.

Space Transportation System Reorganization

Question 30: In January, the National Academy of Public Administration released a report, prepared at NASA's request, on the organization of the National Space Transportation System. The report recommended the transfer of Shuttle operation functions to a new Associate Administrator who would be solely responsible for the management and operation of the Shuttle; the new Associate Administrator who would not be responsible for any space transportation R&D. The report also recommended that institutional responsibility at Kennedy Space Center (KSC) be transferred to the new Associate Administrator.

What is your assessment of this recommendation? Do you belive there might be certain undiscovered efficiencies in establishing a line of authority from this new Associate Administrator down through designated directors at each field center?

Answer 30: The recommendation has merit; however, the lessons from the STS 51-L accident must be identified and considered before deciding on a reorganization design strategy. As the major Shuttle developments approach conclusion, the principal focus of the Office of Space Flight is Shuttle operations. I have asked General Sam Phillips to review the NASA organization, including the organization of the National Space Transportation System and the NAPA report.

Question 31: What actions have you undertaken, or plan to undertake, to streamline Shuttle operations?

Answer 31: Several contract consolidations have taken place over the last few years. These are: the Base Operations Contract (BOC)-awarded to EG&G, and the Shuttle Processing Contract (SPC)-awarded to Lockheed, at KSC, and the Space Transportation System Operations Contract (STSOC)-awarded to Rockwell, at JSC. In addition, a request for proposals for a Payload Ground Operations Contract (PGOC) at KSC has recently been issued. It is expected that the PGOC contract will be awarded and the contractor will be in place by January 1, 1987.

Currently under way are reviews of the program requirements, the operations and maintenance requirements specification document (OMRSD), the Critical Items List (CIL) and the program support requirements.

At this time, we are awaiting results of the STS 51-L investigation and anticipated new requirements prior to initiating further actions to streamline Shuttle operations.

Senator GORTON.

Senator Hollings.

Senator HOLLINGS. Dr. Calio, I thank the distinguished chairman for yielding.

As you know, Senator Heflin and I put in a little measure relative to the geostationary orbiting environmental satellite, the GOES coverage. I have some questions for the record.

I have a group that has been waiting in my office for the past half hour. I am running late, and they will have to leave. I apologize for not being able to ask these questions directly, but we are very much interested in the predicament that you now face with only one satellite weatherwise covering for us, particularly in the Atlantic with respect to the hurricane threats and everything else of that kind.

I have some questions, and I appreciate the chairman yielding so that I can submit those questions for the record.

Senator GORTON. Dr. Calio, we would like to hear from you.

STATEMENT OF HON. ANTHONY J. CALIO, ADMINISTRATOR, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, DEPARTMENT OF COMMERCE, ACCOMPANIED BY DR. PHIL BISHOP; DR. DICK HALLGREN; AND ADM. BILL MORAN

Dr. CALIO. Thank you, Mr. Chairman. I have no prepared statement at this time. I would like to give you an overview assessment of the status and try to describe to you what actions we have underway right now and what our plans are for the very near future.

I handed you a sketch to show you the one satellite versus two satellites situation. As you know——

Senator GORTON. Unfortunately, you have had that sketch for some time.

Dr. CALIO. Yes, I have. Before I begin, I really should introduce the people who are here with me.

To my left is Dr. Phil Bishop, the head of the satellite service. To my right, Dr. Dick Hallgren, head of weather service. To his right, Admiral Bill Moran, head of our aircraft operations. All of us, of course, are involved in trying to assess the current situation.

Yes, we have been in the one satellite situation since July 1984. Even though our common practice is to try to have two geostationary satellites up there, you can see from the two pictures the difference in the coverage that you have in the South Atlantic to be able to give us an understanding of the onset of severe storms that build up into hurricanes on the east coast and also the kind of coverage that we would try to get out of the South Pacific so we can get a better assessment of the storms building up into typhoons.

That could operate in the area of Hawaii and beat up into the Gulf of Alaska, which does indeed affect the northwestern part of the United States. So we have been operating with the one satellite situation since 1984.

We had employed certain activities at that point in time and will continue to do that now. With the unfortunate situation that occurred Saturday night, we are continuing to fly reconaissance aircraft. The requirement for a one satellite system is about 2,100 hours of aircraft flight. On a two satellite system it is about 1,200, and so there is that difference.

We had planned to take the aircraft coverage back to a normal situation. We will continue that aircraft operation. We have no difficulty as far as accessibility to the aircraft. We have equipment, and it is a matter of getting the funds forward to support that effort at the same time in the past. Currently we are able to gain access to two neighboring geostationary satellites, the Mediosat provided by the Europeans on the eastern side, and the GMS, the Japanese satellite, on the western side.

We will still gain access to that data.

Senator **Gorton**. Does their useful camera coverage overlap ours?

Dr. **Calio**. No, it does not, sir. It abuts up close, but we do not really get overlap. Is that right?

Dr. **Hallgren**. No, there is no overlap. Out at the very extremes it may appear as though there is overlap, but not on useful coverage.

Dr. **Calio**. The other thing we have done in the Pacific is we are deploying additional buoys, so we will have a full buoy coverage, more buoy coverage in and around the Hawaiian Islands. All of those are in place, and we will continue to keep them in place.

The additional thing that we have done in the past 2 years is to be able to have direct reception for our polar orbiting satellites to Alaska, Miami, and Hawaii. That is the status of where we are right now.

Let me then tell you where we are with respect to the status of the existing GOES-6. From all indications that we have, that satellite can continue to be used in the same way we have been using it for the last 2 years for 2 more years. The limitation is fuel, and the question is, How do we use that fuel effectively? There is a possibility to be able to stretch that until the 1989-90 timeframe. If we continue the same way we are operating today, we would expect to be able to operate for 2 more years.

As you recall, none of the satellites have in the past lived the expected lifetime. We are expecting this one to live essentially 4 or 5 years. In reality, we have never had any problem with the satellites. The satellites are still up there operating.

We have had problems with the instruments. We think we have taken corrective action with the instruments that are currently on GOES-6, and we have improved them even further on the yet-to-be-launched GOES-H. We have four encoders on the GOES-6. We have used one of them completely now, and it has lived beyond its designed useful life of 5 days. We have gotten something like 807 days out of it, and we have about 250 days on the second encoder.

So we do not anticipate any communication or encoder problems on the current GOES-6. Our best estimate is a very comfortable 2 years using it the way it is now, barring a new major disaster. If we economize, we can even possibly get into the 1989-90 timeframe.

As you also know, we have a GOES-H completing a test, and we expect that to be completed by July of this year. We have not determined yet what is the most prudent plan of action as to whether now we should call it up and launch it in the fall.

We had originally planned to launch it in the October timeframe and to store it in orbit. The main reason for that was to reduce our cost for maintaining the Delta line and running the cost while that line was open.

Incidentally, Admiral Truly got hold of me Sunday and we asked for support from NOAA, and we do have a member on that review team. With that review going on, we may now be in a position to be able to delay when we actually launch GOES-H. The reason we might delay that, of course, is the next buy or the next availability of a block of those type satellites will be July 1989. In September 1985 we signed a contract with Ford Aerospace to buy five geostationary satellites, the first one to be delivered on contract by July 1989.

So the question is, How do we live successfully from now until the 1989 timeframe, when we will have five spacecraft becoming available? We are then looking at several alternatives. The gravest concern we have is to be without any geostationary satellite at all, and that is why I hesitated on when we would plan to launch GOES-H.

We are looking at gap fillers, if I may use that expression. We have contacted Hughes to ask them what would be the performance cost of schedule associated with buying an additional satellite of the same current vintage as GOES-H. We have also asked them to take a look at a lesser satellite which they have developed for the Japanese called GMS.

At the same time, we have gone to Ford, who was the successful contractor for the up-and-coming geostationary satellite and ask them what the performance cost of schedule would be to accelerate their schedule without any sacrifice of the existing program that is in place.

We have asked them to take a look at another alternative. Since they are the manufacturer of the Indian satellite, the INSAT, which has a less capability than our GOES satellites and the one they are developing, we have asked what it would take to be able to buy one of those as a potential gap filler.

We are doing one more thing relative to the ground. We are looking at increasing our computation and data handling capabilities at Hawaii, Anchorage, and Miami so that we will be able to process polar orbiting data in real time so that we can construct images from that satellite to help us in being able to provide increased reconaissance in the western and eastern regions of the oceans.

That pretty much gives you an overview of where we are, where we have been, and where I think we are going. We anticipate in about 6 weeks to have an complete analysis and would be prepared to discuss that with this committee.

Senator GORTON. We have been living with one GOES satellite now for some 2 years. How adversely has that affected our weather forecasting capacity during that 2-year period?

Dr. CALIO. We have lived through that this last couple of years. Let me ask Dr. Hallgren to answer that from the weather service standpoint.

Dr. HALLGREN. You recognize that with the one satellite and the way we positioned it, we got good coverage over the 48 continental

States, and that was for the tornadoes, flash floods, as well as for the hurricanes in their last part of the trip toward the coast.

So with that capability we were doing, I think, as well as we could.

Senator **Gorton**. There is no question but that you are doing as well as you can.

Dr. **Hallgren**. I am sorry. I did not mean it quite that way. I meant that we were doing it as well as we would have done in that zone had we had two, because we had adequate coverage.

Our problems, of course, came up in the fact that the coverage to the east and our ability to track the hurricanes before they arrived on the island chain down around Puerto Rico is inhibited. We did not have as good information to the east of there and out in the Hawaiian area and up in the Alaskan area. Obviously, without that type of valuable information we would not have done as well in some cases as we would have with the satellite.

Senator **Gorton**. How much would our forecasting ability suffer if we lost the one in orbit and could not replace it during the time in which there were none operating?

Dr. **Calio**. Let me try to tell you how we work it, and then I will ask Dr. Halgren to expand on it.

We would be relying solely, then, on developing imagery through analysis of the polar orbiting satellite data. As you know, that circles the Earth about 16 times a day on the Equator. It covers about one location twice a day. Its swatch is about 150 to 160 miles, so we have to build up a mosaic of imagery to be able to tell you what the cloud cover was.

This would put a tremendous strain on our aircraft operations because we use that reconaissance to be able to dispatch and develop our aircraft coverage. We would probably have to increase that tremendously. The inner circle, incidentally, provides you with the winds aloft, and we would be without that data with the exception of using ground equipment, like radar systems and the like. So we would have to lean more heavily on our radar.

For the ultimate effect, I would turn to Dr. Hallgren.

Dr. **Hallgren**. Now, we would not have that coverage of the United States. As Tony just indicated, we would have great difficulty tracking hurricanes with the precision that we have in the past, even when they get close to the coast.

Over the continental United States, let me try and give you something that you can take hold of. Our capabilities of issuing watches in this country related to severe thunderstorms and tornadoes has substantially improved by our verification statistics over the last 5 to 10 years. The improvement has been upward toward 50 percent. Quite frankly, if I had to guess, we would lose about half of that increase in capability if we lost that satellite.

With regard to warnings themselves, the most important tool in the issuance of a warning is the radar, but there are situations where the forecasters find that the satellite information was more valuable. I cannot give you statistics on that, but there would be certain situations in which we would not do anywhere near as well and would miss a flash flood or tornado warning.

Senator **Gorton**. It does seem to me from the testimony, Dr. Calio, that you have accomplished a great deal since last Saturday in at least beginning to examine what the alternatives are.

For my purposes and the subcommittee's purposes, however, first tell me how much more sophisticated the next generation, expected to start in 1990, will be. Will they be a quantum leap ahead over the GOES satellites?

Dr. **Calio**. We have tried to assess that in the general sense, and we come up with about a factor of eight improvement. That is a figure of merit, and it takes place in several different ways.

We have increased the spectrum capability, the sounding capability, and the response time of the instruments so that we would have the sector coverages in different higher resolution and would be able to sample faster.

Let me ask Dr. Bishop of the satellite service to walk through that.

Dr. **Bishop**. Mr. Chairman, there is one dramatic change in the geosynchronous satellite of the next generation which goes from I through M, and that is the addition of an operational sounder from geosynchronous orbit to measure temperature profiles in the atmosphere. That can be done continuously without interrupting the operation of the imaging instrument which provides the pictures.

That will also be steerable so that we can take the soundings in clusters in the area where the action is taking place if the weather service needs that kind of capability.

The imaging instrument itself is also an improvement. The existing satellites, as you know, are spinning satellites, so every time they pass by they take one streak across the continent. As a result, it takes about 30 minutes to build up a picture. With the new satellite we can build a picture much more rapidly, in a matter of minutes.

The camera, if you wish, is steerable, and we can zoom in on the area where the action is and get repeats in the local area in a matter of many seconds. So this provides a kind of flexibility in the operation of the spacecraft and the providing of data to the weather service which we have just not had to date.

Senator **Gorton**. Who is the manufacturer of the new satellite?

Dr. **Bishop**. The new manufacturer is Ford Aerospace, and the present manufacturer is Hughes.

Senator **Gorton**. Is the Indian satellite manufactured by Hughes?

Dr. **Bishop**. The Indian satellite is a multipurpose satellite. Its main use is communications, but it has a weather observing instrument. It is manufactured by Ford.

Senator **Gorton**. Are there other manufacturers anywhere in the world of satellites which are useful for weather information?

Dr. **Bishop**. There is, of course, RCA Astro in Hydestown, NJ. They may bid on this particular procurement, and they would be capable of building such a satellite. Mediosat is built by a combination of companies in Europe.

Dr. **Calio**. The Japanese satellites, up until now, have been built by Hughes.

Senator **Gorton**. Now, let me review and see whether I got, Dr. Calio, from you what your alternatives are. You are examining whether or not you can accelerate the construction of this next generation of satellite without compromising quality for the things that it can do.

Did you also say that you are asking that same manufacturer whether it can build a less complicated satellite more rapidly?

Dr. CALIO. Yes.

Senator GORTON. You are examining whether or not to build another GOES or maybe more than one other GOES through Hughes?

Dr. CALIO. Yes, sir.

Senator GORTON. You are examining whether or not Hughes can build a simpler satellite than the GOES even more rapidly than that?

Dr. CALIO. Yes.

Senator GORTON. You are attempting to determine whether or not the kind of satellite being manufactured for India is something you could do relatively quickly and inexpensively?

Dr. CALIO. Yes.

Senator GORTON. I am up to five now. Did I miss one, or is there any more?

Dr. CALIO. That is it as far as satellites are concerned, yes.

Senator GORTON. Those are the satellite alternatives that you conceivably have?

Dr. CALIO. Yes.

Senator GORTON. Obviously between last Saturday and today you have gone no further than to ask these potential manufacturers what they might be able to do?

Dr. CALIO. That is correct, and we are weighing that against the scenario of delaying the launch of GOES-H.

Senator GORTON. Are you also looking at whether GOES-H can be sent up in something other than a Delta?

Dr. CALIO. We have no other choices at this particular point in time. It is configured for a Delta. We have not looked at the Titan launch vehicle, and I do not think it is configured at all for the Atlas-Centaur. We have not intiated any studies at this point or worked with NASA on starting any studies to look at that right now.

Senator GORTON. How about the polar orbiter launch on an Atlas scheduled for this summer? Do you think that that could go forward?

Dr. CALIO. We are moving forward with the schedule right now. We have to work more closely, and we are working closely, with both NASA and the Air Force to decide, based on the last series of incidents, whether we should stand down or not.

We still have time. We would like to get it up on June 16, but we want to make sure that we are confident in having that launch.

Senator GORTON. What about cost? I take it that you have to eat the whole cost of the last GOES and you have to pay NASA even though the launch was not successful?

Dr. CALIO. We have to pay them up front, as a matter of fact. The bill has been paid.

Senator GORTON. You are not going to recover?

Dr. CALIO. No, sir. It is all the Government, sir. It is one side or the other.

Senator GORTON. That is true.

Senator Gore.

Senator GORE. Thank you very much, Mr. Chairman.

I just have a few brief questions that Senator Hollings would have explored if he could be here, and I will explore these as a courtesy to him.

South Carolina and other coastal States rely on the satellite for hurricane prediction, and as I understand the situation, in the absence of the second satellite, you have to reposition this one at the beginning of the hurricane season to give adequate coverage to predict hurricanes on the east coast?

Dr. CALIO. Not quite. We move it to get extended coverage into the South Atlantic region, so we can disperse our aircraft. As you look at that single satellite picture, and the picture you are looking at there is actually in the middle of the United States, we move it just slightly over to the east, to 98 degrees in the summertime and to 180 degrees in the wintertime to give appropriate ocean coverage.

But once the hurricanes have moved into that central region, we can track them very well with that single satellite.

Senator GORE. Well, essentially the response is yes, you move it to the east at the beginning of the hurricane season, is that not right?

Dr. CALIO. Yes, we do move it to the east just a little bit, not very much.

Senator GORE. But with only one instead of two, you have to move it to the east at the beginning of the hurricane season?

Dr. CALIO. Yes.

Senator GORE. Then when the hurricane season is over, you move it back to the west, right?

Dr. CALIO. Well, we move it further west so we can cover the Pacific Ocean.

Senator GORE. You move it back to the west, right?

Dr. CALIO. Literally, that is right.

Senator GORE. Thank you.

Now, moving it to the east and moving it back to the west consumes fuel?

Dr. CALIO. That is correct.

Senator GORE. Now, it started with about 80 gallons of fuel, hydrazene I believe, correct?

Dr. CALIO. Pounds, yes.

Senator GORE. Now, you have about 44 to 48 pounds left?

Dr. CALIO. That is correct.

Senator GORE. Normal operation of the satellite, meaning keeping it stabilized, consumes about 18 pounds of fuel per year, correct?

Dr. CALIO. That is correct.

Senator GORE. Now, you have got to leave 5 pounds in the tank for when it is all through in order to boost it out of its orbit, to keep it from becoming space trash, right?

Dr. CALIO. That is correct.

Senator GORE. Now, the problem is that each time you move it at the beginning of the hurricane season and at the end of the hurricane season, you consume an extra 4 pounds with each repositioning, correct?

Dr. CALIO. That is correct. The way we are doing it today, that is correct.

Senator GORE. So you face a tradeoff between repositioning for improved hurricane prediction and the lifetime of the satellite?

Dr. CALIO. Correct.

Senator GORE. Have you made the decision to definitely reposition for the hurricane coverage this year?

Dr. CALIO. Would you state your question one more time?

Senator GORE. Have you already made the decision that you definitely will reposition the satellite using that 4 pounds and then the total of 8 pounds?

Dr. CALIO. Yes.

Senator GORE. You have?

Dr. CALIO. Can I make one other statement?

Senator GORE. Sure.

Dr. CALIO. The consumption of those 4 pounds can change based on the rate at which we move it. We are going to move it, but we have not decided yet at what rate we shall move it.

The same thing is true for the north-south stationkeeping. As you indicated, a great deal of fuel is consumed in north-south stationkeeping. We can change that condition as well. Instead of holding the one-tenth of a degree that we are holding right now, we may be able to move it a little further and let it go north-south two-tenths or three-tenths or half a degree.

That consumes most of the fuel. As you pointed out, 18 pounds per year is consumed to stationkeeping that satellite. We have not looked at all of those tradeoff issues yet. We can conserve fuel by changing our north-south stationkeeping conditions and changing the rate at which we move east-west.

Senator GORE. So you have the option of allowing it to drift a little bit off the course it would normally keep and thereby save fuel, not only north-south but also at a slower rate east-west.

Dr. CALIO. That is right.

Senator GORE. You are exploring that option, but you have definitely made the position, or made the decision to reposition at some rate, but to reposition in time for the enhanced hurricane prediction in the hurricane season this year, correct?

Dr. CALIO. Yes, sir.

Senator GORE. All right, fine.

What are the chances that the satellite might fail prematurely? Have you analyzed that?

Dr. CALIO. Yes, sir. That is why we went through. Where we see the limitation is in fuel. From all of our assessments to date, communications, power, encoders and the like, we have anywhere from 3 to 7 to 10 years of life left in that spacecraft, barring a catastrophic failure.

The limitation is 2 years on the fuel if we continue to consume it the way we have in the past 2 years.

Dr. HALLGREN. That does not mean the satellite will become useless at the end of those 2 years. We will not be able to do the stationkeeping as well, as you were reflecting, on the north-south and the east-west.

But we have operated satellites before for periods of time. They are degraded, but we can still get useful information whenever they are moving north and south a degree or two.

Dr. CALIO. Can I make one more point? We still have five geostationary satellites in orbit. We have not kicked them out because they serve other useful functions, either for communications or partly collecting certain segments of data. So we keep those satellites in orbit until we are absolutely sure there is no further use for those satellites.

Senator GORE. All right.

Thank you very much.

Senator GORTON. Thank you. Thanks to all four of you for coming here and helping us and enlightening us today.

Dr. CALIO. Thank you, Mr. Chairman.

Senator GORTON. Mr. Brizendine, and I understand that you have some other people with you. So please come forward.

Given the lateness of the hour, Mr. Brizendine, I want to thank you for your patience. Your entire written statement will be included in the record and we would appreciate you summarizing it, so we will have a chance to ask you questions.

Would you introduce the people with you.

STATEMENT OF JOHN C. BRIZENDINE, CHAIRMAN, AEROSPACE SAFETY ADVISORY PANEL, NASA, ACCOMPANIED BY HERB GRIER; DR. SEYMOUR HIMMEL; MELVIN STONE; JOHN McDONALD; AND CHARLES DONLAN

Mr. BRIZENDINE. Thank you, Mr. Chairman. Beginning on my left is Mr. Herb Grier. These are panel members and in some cases panel consultants.

Next to Mr. Herb Grier is Dr. Seymour Himmel, on my left. To my right, Mr. Melvin Stone, Mr. John McDonald, and Mr. Charles Donlan.

Mr. Chairman, Senator Gore, we have submitted, our written testimony, and you have our annual report for the calendar year of 1985. I think you are aware that that report was completed before the *Challenger* accident, and thus it does not in any way discuss the *Challenger* accident.

However, in consideration of the unique circumstances, we thought we would report this year somewhat differently and break our report into three sections, taking from—in part one, taking from our annual report those items which potentially could have bearing on the 51-I associated activities; a part two in which we have revisited points from our prior year's report, with the possibility that some points there may be applicable to the current introspective examination of the national space transportation system.

Third, what the panel might do to assist and thoughts that the panel might have in returning to safe and successful space flight.

I will deal just briefly with these and pass over most of them. I would mention that during calendar year 1985 the panel conducted 54 separate factfinding sessions at 18 different sites around the country, both at NASA facilities and contract facilities and things of that nature.

Our focus was directed in large part on the space transportation system, its major flight and ground elements, the mission rates, the evolutionary changes that are happening in management, and the operations at both Kennedy and Vandenberg.

We did have opportunities to follow the space station program definition phase and looking at its current management approach and continued the review of NASA's aircraft operations, including the experimental aircraft, the X-29 forward-swept wing and the X-wing rotor system research aircraft.

We looked at special areas of special interest, and that includes the shuttle Centaur and the radioisotope thermoelectric generators involved there. The panel conducted a special review and requested the Administrator to review the LEASAT salvage plan before that mission was attempted.

Briefly, a few points regarding the space transportation system. The panel said in its report that the system performed in a highly credible manner during 1985. It did, with an increasing launch frequency coupled with a number of organizational, operational, and key personnel changes.

The Government and industry program team demonstrated, we believe, its ability to contend with real time anomalies in both hardware and plant. The LEASAT salvage mission is an outstanding example. I think this in an important point that we should make, that the annual report notes: "That a safe and productive space transportation system program can be carried out if the system's real state of the art and other limitations are recognized and integrated into the program planning and scheduling."

In support of this thesis, the panel has made about five points. There are a number of principal systems and components in various stages of modification and improvement, including the main engines, the general purpose computers, the auxiliary power units, and things of that nature. These are to provide performance and reliability improvements, as well as to help compensate for the difficulty in obtaining spare parts on the systems that were designed 10, 15 years ago, and they are very difficult to get parts for.

Second, meeting the increased flight rate will require additional brick and mortar facilities at Kennedy Space Center for processing and maintenance of the shuttle fleet.

Third, the human resources that are being applied to the various space transportation system elements and the launch processing cannot fully compensate for shortfalls, regardless of how dedicated the human effort is, cannot compensate for shortfalls in physical resources or shortfalls in planning and scheduling. It is just impossible.

Fourth, the logistics support, including sustaining engineering and maintenance plan, remains a current and future concern to the panel.

Last, the question of the impacts of budgetary allocations to this program and the new and challenging programs, such as space station and the transatmospheric vehicle and the resulting competition for talent and manpower that those create, give the panel cause for concern: Is there enough talent to go around? I think that has been alluded to earlier today.

The panel is concerned about flight crew training being continued. I think the unique flying qualities of the orbiter will not forgive any compromise in the training syllabus that is required, and thus NASA must provide training systems and the training aircraft equipment for the astronauts to train.

The existing aircraft are accumulating quite a few hours and lots of fatigue cycles, and they are requiring a good bit of down time for maintenance and inspection. So training is an important subject.

The main engines of the shuttle. We have talked about quite a bit of money today and various things, and we are going to talk about more. I do not know how much. The panel believes it is essential that the space shuttle main engine improvement programs be pursued to their fullest. This includes the phase two, the phase two plus, and the precursor improvements we believe are required to provide reliable and durable engines with adequate margins up to 109 percent thrust.

The program will benefit through flexibility of this, and ultimately it will cost the country less to operate the system because of the more durable and reliable engines.

We should mention solid rocket boosters, which are getting a great deal of attention these days. The past year, 1985, the panel's principal focus on boosters was with the filament wound case as it was coming into being, rather than the steel case.

However, in years past the panel has had a number of factfinding sessions with members and consultants of the panel who are knowledgeable in propulsion systems at a number of sites dealing with solid rocket boosters. This includes Morton Thiokol, Hercules, the Kennedy Space Center, and Marshall Space Flight Center.

The field joint has been reviewed. No indication was given that the joint was a major concern based upon the available data base. I think it is important to note that the development motor test, qualification test, and laboratory tests did not show any seal problems, and continued flight with the steel cases and the use of a similar design for the new and more flexible filament wound case indicated that there was an awareness of the joint and its capability.

The panel was not aware of the joint rotation problem and the extent of the damaged Oring seal issues. For whatever reason, we were not aware of it. We have been examining the possible reason for that, but for whatever reason we were not aware of it.

With regard to the filament wound case, the panel's findings and recommendations have noted that:

> We wish to note that the uncertainty of the structural strength of the filament wound case tests and analyses to date leave considerable doubt as to the strength margins of safety in the transition area between case segments. Until that issue can be resolved with a high level of confidence, the panel believes the filament wound case solid rocket boosters should not be used for an STS launch.

There are other matters of logistics and launch processing that the panel has concerns about, that your staff and yourselves can see in our written submittals. I would say that the shuttle-Centaur is of continuing concern to the panel.

Our concern actually stems from the complexity of the payload installation in the shuttle, with the payload's cryogenic fuel venting requirements in the bay of the shuttle, all of that coupled with a very tight schedule to accomplish the checkout and certification literally on the launchpad before launching.

There is, further, the problem of dealing with the venting of the fuel in the case of an abort launch. Further in addition is that this was going to be the first launch of the 109 percent thrust with the engines. I must admit, I heaved a sigh of relief that it was not going to be launched in May of this year. Hopefully all of these issues can be resolved before, and satisfactorily, before a new firm schedule is made for a shuttle-Centaur launch.

The space station concern is principally related to organization and whether or not the space station work will benefit from the lessons learned on the space transportation system. There are many lessons to be learned. We believe that NASA should take advantage of that, and in fact we recommend that NASA appoint a team of experienced personnel to review the shuttle program lessons and try to apply them to the space station.

The organization and management set up for space station is complex and it is most likely going to get more complex with time. Hopefully, something is going to be done to sort that out, to simplify the management process. We understand that NASA is considering that.

The panel further questions the wisdom of NASA trying to perform the full task of systems engineering and integration in-house. In addition to the heavy demand on NASA's resources, this would leave the corporate memory of this program only with NASA and nowhere else in the country.

I would like to skip our points from previous reports and let your subcommittee review them separately and go directly to part three of our report, which will discuss the panel's observations and suggestions which it would like to make with respect to returning to space flight.

First of all, we would like to say that the panel applauds Admiral Truly's conservative strategy for returning the system to space flight. The panel believes that the NASA management is not flawed. NASA has had in the past and continues to have a systems management capability in place that has functioned well through many programs, and it does contain three key elements of system integration, what we could call a technical conscience, and check and balance.

The system is there to provide those things. If a flaw does exist, it may be in the use of the system or the application of its principles. Perhaps with age and repetition these things may have grown somewhat stale and routine in their application. Complacency may have set in a little.

But the panel believes it is worth examining, and if it in fact turns out to be the case then, rather than reinventing the wheel or a whole new program management structure, it might be well to consider revitalizing the existing structure and streamlining the current program and project structure and reporting lines.

The panel does recommend that an external or, preferably, internal, if it can be achieved, group be established to gather and analyze data necessary to define the operating margins for the various STS elements, so as to improve risk management.

The assessment of risk and identification of the margins, and the operational controls to operate within those margins, are truly integral parts of the flight readiness and certification process. But the key to being able to do that is to determine what those margins are, and then manage the operations so that you stay within those margins.

Third, we believe we must remind ourselves that in the development of any complex system, two major and complementary activities are involved. One is designing to achieve the desired performance, to achieve the goals and objectives; and the other is identification of the uncertainties, and assessment of associated risks under which it is accomplished.

These two functions or activities require quite different mental attitudes by people involved, and separate groups of people should be involved in performing those functions.

Fourth, any mission—or for any mission, the critical failure points in ground processing are just as important as those for the flight hardware. The ground processing activities deserve further review.

Fifth, the mandatory inspection points have changed with time for the space shuttle elements. These should be reviewed along with the integrated maintenance plan, to see if perhaps the inspection program should be backed up a bit, or revised in some manner.

The next launch will be essentially a test flight, as we see it, and we believe the launch should be well within the experience base to the extent possible. And I think that fits well with Admiral Truly's strategy.

We would note—and I think this is important for the subcommittee to note—that the STS program has 25 flights now in its data base, and each flight the hardware of the system has been telling us something. It has been giving us feedback. It has been telling about itself, its health.

Every anomaly from every flight should be reviewed and satisfactorily corrected or explained, and we believe this is as important, probably more important, than the review of the critical items on the critical items list that you have heard discussed a great deal this morning.

The category 1 and 1-R critical items list are being revalidated, as Admiral Truly has discussed. The large number of those is a bit mind-boggling. There is something over 2,000 items on the list, and there were developed through the failure mode and effects analyses. And this indicated a thorough job of analyzing, on paper, the possible failure modes and effects.

But it does not necessarily provide for good risk management. The nearly 1,000 items that are remaining—I think that number could have been added up this morning. I did not quite do that. But those on the CIL, nearly a thousand that are without waivers, we believe are really too many to manage effectively.

And I think we have to ask ourselves, should anything be flying with nearly 1,000 category 1 and 1-R items on it? So the panel suggests that those items, those critical items for which you can demonstrate margin from its failure modes be separated into another category, and the attention be given to the real, truly category 1 and category 1-R items. We would call them the "zingers," the ones that you really need to look out for.

We believe that, semantics or treatment with analysis of the margins that that number can be reduced to a manageable, or more manageable list. We believe that this action plus uncompromising attention to the flight anomalies, each flight should really help management's task of minimizing risk.

The program plans and schedules must be integrated with the funding plan. You gentlemen are searching for the funding plan. Our point is that the program plans must fit within the funding level that has been allocated for the program, and not pushed beyond it.

For the return to flight status, however, an adequate funding level is going to be required. It is going to have to support all of the work that has to be done in the elapsed time that it is going to take to accomplish the hardware redesign, and the testing, and the recertification resulting from the accident investigation.

Last, we would suggest that coordination with, and an understanding, by NASA and DOD, and the contractors, and the Congress, on a continuing basis is essential in returning to space flight as safely and as promptly as possible. And we would be happy to entertain any questions you might have.

Senator **Gorton**. Thank you.

Senator Gore.

Senator **Gore**. I appreciate your courtesy, Mr. Chairman. I know both of us have pressing schedules, but I appreciate it very much.

Mr. Brizendine and members of this panel, I think the country owes all of you a debt of gratitude for your willingness to serve in this volunteer capacity that takes up an enormous amount of time and to provide the country with the benefits of your judgment and experience. And I know that I speak for a lot of people in saying that we appreciate it, a lot of people do. And so thank you very much.

Everything is being reassessed in the wake of the *Challenger* tragedy, and your panel has not been immune from taking a few barbs along the way on the O-ring matter. You confronted this head-on in your statement, and I think that is wise.

And you said in the 1985 report: "The seal problem was well in hand and attended to." Is there anything that has come out of your introspection in the last weeks and months about the way you looked at—the way you came to that conclusion, that would lead you to recommend changes or ways we could beef up the way you go about your task? More staff, some other procedures, or do you have any recommendations along those lines?

Mr. **Brizendine**. Well, the panel has taken it on itself to, let us say, tighten up our own ship, so to speak, to better focus on or maintain focus on the truly important items relating to safety, so that we do not miss the critical ones, if that is possible.

It is not possible to catch everything. Nobody humanly—I mean, we are only 9 people plus some consultants, maybe 14 all together. And on any given subject, we can get about a millimeter deep, although we do have people with expertise in various fields, and they do speak in some depth technically on individual questions.

But by our own disciplines, we believe in taking the initiative with the sources of information, be it with a contractor or a NASA center or wherever, and our own disciplines and trying to maintain our own focus on the truly important items and keep the wheat and the chaff separated. We believe that we can enhance our ability to do a better job.

Our face is red that we did not see that problem, but we did not.

Senator GORE. Well, I thought it was thoughtful and appropriate for you to add that item of how you could improve the panel's performance to your own agenda, and I welcome that and wish you well as you continue that effort.

On the subject of quality control, that has been mentioned repeatedly here today. I note in your past reports several references to quality control, and it would seem from a reading of your reports that you have noticed in a variety of different areas some shortcomings in quality control.

First of all, is that a fair summation of what you have looked at in the past? And second, in bringing all of the quality control problems together in the way that the figures we have talked about today do, do you agree that here is a systemic problem with the level of resources devoted to quality control in NASA and that that should be turned around?

Mr. BRIZENDINE. That is a multifaceted question. The panel has paid attention to the subject of quality, and I think along that line we would urge NASA and the contractors to review all of our reports for things that might be useful to them. We would be happy to work with them.

We did address the subject of quality control in a number of them in recent years. I think we look at quality very broadly. It is not the flashlight-and-mirror-type inspection, but quality control can affect many, many things. "Quality assurance," I think, is the more nominal term these days.

But it does go from the inspector looking at the part and the instructions and stamping it out and so on, all the way up into the management levels.

Senator GORE. In other words, quality control includes not only identifying problems and potential failures, but also making certain that they are corrected?

Mr. BRIZENDINE. That is correct, if there are problems.

Senator GORE. And if the examination of something like the SRB identifies a problem, that is part of the task. But if there is a breakdown in the insistence that that be fixed, then that is a breakdown in quality control also.

Mr. BRIZENDINE. That could be treated that way, yes.

Senator GORE. Well, go ahead. What about the overall view of quality control at NASA? Are you startled at these figures, as I was?

Mr. BRIZENDINE. They seem rather dramatic when displayed in this fashion. I would caution premature conclusions based on those figures. I think it would be worth following up to understand what those figures mean.

There has been a change in requirement for perhaps the type of people that these figures represent, because there have been fewer programs in process and the evolving status of the STS program as well. And so there well could be justification for this.

It is very possible that it could have swung too far. I do not know.

Senator GORE. Well is it not true that you have noted numerous instances in your past reports of quality control deficiencies in various aspects of NASA programs?

Mr. BRIZENDINE. We have urged continued attention to quality, and I think we said in one report that quality is everybody's business every day. That is what is required to give the level of quality you want.

Senator GORE. Mr. Chairman. I appreciate your courtesy, and again I appreciate the work of the panel.

Senator GORTON. Senator Gore spoke for all of us in thanking you for the service that you provide and the very, very fine tradition of public service and of inestimable value as well.

I would like to—and unfortunately, when you get put third on one of these panels we run short of time. And I will have a number of questions that we would appreciate your written answers to as well.

But a couple would include this. Your panel indicated that, given the funding limitations of the space transportation system, it should be scaled and planned to do a useful and constructive job within these budgetary limitations. As a matter of fact, you said that very specifically in the course of your testimony.

In your opinion, has NASA compromised safety in its attempts to do too much in recent years in the shuttle program, given those budgetary limitations?

Mr. BRIZENDINE. Well, Senator, there has been no conscious compromise of safety that any of us has witnessed, I believe. I do not think we can say that there has been a compromise of safety in that regard.

There is a propensity to reach out and do great things with this wonderful machinery.

Senator GORTON. And that is not all bad, either.

Mr. BRIZENDINE. No, it is not. If we do not stick our necks out a little bit we are never going to get anywhere. But we believe with a program such as the STS it is necessary to size the appetite for achievement to what you truly can afford and scale it to that.

If the Nation has so much to spend on it, that is what we should spend it on, and then we should size our goals to fit within that, our program. You know, these programs run through a lot of different years, as you well know. If we set our sights too high, way out here we are going to run out of money. We are going to affect the outyears, we are going to affect a whole lot of things.

Perhaps the brake problem today stems from not putting the money in the right place 10 years ago or 15 years ago, as an example. So I think this is a point that the panel feels that, know your available funds and put your program within an envelope that those funds will support and do not try to get outside that until you have the funds.

Senator GORTON. On another subject, given the *Challenger* accident and given the cost and technical problems which have arisen in the Centaur program, are you concerned about the use of radioisotope thermoelectric generators in combination with Centaur on a manned vehicle?

Mr. BRIZENDINE. I do not really know whether manned or unmanned makes any difference in that question. Mr. Grier is our expert in that field.

Mr. GRIER. I think we are concerned, yes. But I do not think to the extent of saying that it is clear that you should not do it. I think we would have hesitated and probably would not have recommended that you fly the plutonium aboard the Centaur in the shuttle this May.

I think as they work on the problems and as they improve the statistics, if you will, the chances of failure, you can then go. There has been some history on failed rockets carrying nuclear generators. They have not been catastrophic from the public point of view. But that may be luck, too.

I know of no other way to do it. I am an experimenter at heart, and I would say, with a properly certified shuttle and a properly certified Centaur, the additional risk would not be high.

Senator GORTON. In any event, you will keep this study and these questions as a priority, I assume?

Mr. GRIER. Absolutely.

Senator GORTON. Again, I want to thank you very much. I am sorry, I am going to have to submit the rest of my questions in writing because of the exigencies of time.

The services that you provide to your country and to the Congress and this committee and NASA are important and are appreciated greatly. Thank you very much.

Mr. BRIZENDINE. Thank you, Mr. Chairman.

[The following information was subsequently received for the record:]

QUESTIONS OF SENATOR GORTON AND THE ANSWERS

Question 1. Has there been anything in the Panel's review of NASA's Space Transportation System that, in retrospect, could be characterized as a clue or a contributing factor to the Challenger accident?

Answer. In retrospect, there are a number of factors that might have contributed to the Challenger accident. Among them is the success of the first 24 launches. These successes may have fostered the delusion that "success-oriented" plans and schedules are always achievable. Such a belief could have led to a relaxed, if not complacent, attitude toward the Herculean and exacting effort required for each launch including, perhaps, a dulling of the sensitivity to and fear of the innate risks of space flight at this stage of its evolution.

Another contributor might have been the fact that the bulk of NASA's experience lies in the research and development aspect of systems rather than in their operational aspects. Whereas NASA has performed the former aspect superbly, long-term operational requirements involving repetitive use of hardware and other associated disciplines were new to most of the NASA team.

Yet another possible factor was the intrusion of political hassles, budgetary disputes and uncertainties and "turf battles" into NASA management's already large scope of concerns. Such intrusions undoubtedly diluted NASA's concentration on the critical tasks of overseeing the development of an operational STS and the management of the risks inherent therein.

Finally, albeit probably less directly, the absence of a clear National Space Transportation Strategy and supporting programs may have been an underlying contributor.

Question 2. Given the information that has been revealed in the Challenger accident investigation, should your Panel have been aware before the accident of certain deficiencies that may have contributed to the accident?

If so, were you unaware due to the scope of your Panel's mission or due to NASA's inadequate provision of information?

Answer. The Panel was certainly not aware of either the extent of concern regarding the seals of the field joints or of the Damoclean nature of the mounting physical evidence of seal damage during flight.

The scope of the Panel's mission is adequate for it to have been informed of the issue. The lack of such information probably has its roots in the first and third paragraphs of the above response to Question 1.

Question 3. In your January 1986 report, you have expressed concerns about NASA's ability to meet its launch rate projections. Do you believe that there is an institutional reluctance at NASA to use realistic assumptions in developing launch rate projections? If so, how can this be remedied?

Answer. Aggressive schedules are an important tool for the achievement of optimum performance in any organization. Otherwise, left to an unstimulated pace without challenging goals or targets, an organization will tend to drift along with resultant very low productivity for the resources applied.

NASA management probably had set very demanding goals for flight rate partly for the reasons stated above and partly for political reasons. For example, would Congress fund one flight per year?

The Panel DOES NOT believe that there is an institutional reluctance to schedule realistically. Rather, it believes it important for management's true policies and priorities to be conveyed to the working-level managers whose *perception* thereof will direct their performance. Clear vertical communication is essential in the organization—the lower level staff must know, for example, that their leadership places technical excellence and safety above compliance with a schedule.

Question 4. According to the Panel's 1986 report, which assumes the existence of a four-orbiter fleet, NASA could have attained, with difficulty, a flight rate of 12 to 15 flights per year, for the next 2 to 3 years. Under the present circumstances, what is a realistic flight rate for a three-orbiter fleet? A four-orbiter fleet?

Answer. In the Panel's opinion, achievable flight rates would be:

Three Orbiters—9 flights per year.

Four Orbiters—12 to 15 flights per year.

With a mature STS and all its supporting infrastructure, approximately one additional flight per Orbiter per year would appear possible.

Question 5. According to your testimony, the Filament Wound Case should not be flown until questions about its structural integrity are resolved. What is the basis for your position, and do you believe that NASA is giving adequate attention to these concerns?

Answer. The basis for the Panel's judgement regarding the Filament Wound Case (FWC) includes:

a. The FWC has not yet been shown to be structurally sound by test verification of the design; indeed, the contrary is true. No primary-load carrying structure of this type should be flown until satisfactory engineering verification of the design has been achieved. The structural test article (STA-2) failed at 118% of limit load, well below the required 140% of limit load. The failure mode itself is not fully understood.

b. The state of knowledge of the behavior of composite materials applied in primary-load carrying structure is much less advanced than that of homogeneous metallic materials. The technology of composite materials employed in primary structure is still developmental.

c. Non-destructive evaluation and inspection techniques applied to such structures is also developmental and inconclusive, and hence not very reliable.

NASA has the best minds in the country working on the problem. The Technical Assessment Overview Group established by NASA notes that, for example, there should be a full-scale static test to failure to help establish physical characteristics and true capability.

Question 6. Do you believe that the Filament Wound Case can be flight-qualified independent of any redesign of the solid rocket booster?

Answer. Possibly, but it should not be done until current FWC problems are completely resolved and dynamic tests accomplished. The FWC has its own unique set of required proofs to be flight qualified. The segment joints could be qualified simultaneously with the other critical areas. Note, however, that one of the known weak spots in the FWC is in the composite-to-metal transition area and the "double clevis" joint which must be qualified.

Question 7. In its 1986 report, the Panel has expressed concern about the ability of the Centaur program to complete its certification testing. With the additional time now afforded the Centaur program, do you believe that these certification tests can be acomplished on time, and will these tests adequately answer all safety and technical questions?

Answer. The Panel believes there should be no "on-time" constraint on Centaur. The numerous technical problems must be solved first. Then, and only then, if the assessment of residual risk is judged acceptable, and if National priorities permit, it could be flown.

Question 8. For the past two years, NASA has encountered significant cost overruns and technical problems in the Centaur program. What has the Panel identified in its review of the Centaur program that has contributed to these cost overruns and technical problems?

Answer. The task was grossly misunderstood and hence underestimated from the beginning. One reason is that the design, initially on an unmanned basis, has steadily evolved toward a "man-rated" vehicle. Once understood, the true costs come to light. The Centaur is no ordinary payload and it must be *integrated* into the orbiter systems unlike other cargos in the payload bay. "Shuttle/Centaur" may be an unacceptable concept to meet reasonable risk criteria.

Question 9. In your statement, you have drawn attention to a 1982 recommendation by your Panel that stresses the need to establish an "audit" team of experienced R&D systems engineers to review the design of Shuttle systems for reliability and safety.

Has NASA adequately responded in the past to this recommendation, or, in the opinion of the Panel, is NASA now adequately performing this function in its review of all criticality-1 items?

Answer. NASA has responded to the Panel's 1982 recommendation for a systems engineering audit of the Shuttle but not as fully as the Panel would have wished. Again, the level of response is related to the degree of importance attached to the recommendation by middle and upper management levels. The Panel was, and still is, concerned with the consistency of applied reliability (particularly, the use of redundancy) and safety criteria. We believe this sort of fundamental reexamination should be invoked during the current re-review of CILs. We know that an intense and diligent review is under way. To enhance safety, the process must be more than reviewing the paper analyses that were created years ago. The task is enormous and exacting. Some controlling criteria must be applied across-the-board, in a manner in which everyone involved understands. The Panel has no direct way of knowing if the process is "adequate"; this will have to be judged on the basis of standards applied and results measured against them.

Question 10. The Panel has indicated that additional "bricks and mortar" facilities are required at Kennedy Space Center for orbiter processing and component maintenance.

What are these additional facilities, when will they be needed, and what is the estimated cost to build these facilities?

Answer. The Orbiter Processing Facility (OPF) at KSC is scheduled for major refurbishment, but the Panel has seen no confirmation that the update work has been funded. An additional Orbiter and Maintenance Repair Facility (OMRF) was also to be part of this program and such additional facilities as shops and equipment for making the tiles for the Orbiter Thermal Protection System were to be included. It would seem that, with "down time" available, the opportunity for proceeding with this program is now afforded. We do not have any cost data.

[Whereupon, at 1:10 p.m., the subcommittee was adjourned.]

NASA AUTHORIZATIONS

TUESDAY, AUGUST 5, 1986

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE,
Washington, D.C.

The subcommittee met, pursuant to notice, at 10:04 a.m. in Room SR-253, Russell Senate Office Building, Hon. Slade Gorton [chairman of the subcommittee] presiding.

OPENING STATEMENT BY SENATOR GORTON

Senator GORTON. Welcome to this hearing of the Subcommittee on Science, Technology, and Space as it completes its fiscal year 1987 NASA authorization hearings.

When this subcommittee began its series of hearings on the NASA authorization earlier this year, the budget overview with the NASA Administrator had to be unavoidably postponed. As the subcommittee worked its way through the other NASA authorization hearings, events overtook our ability to reschedule this budget overview hearing until today.

Nevertheless, the subcommittee is pleased to have with us Dr. Jim Fletcher, NASA Administrator, and Mr. Tom Newman, NASA Comptroller, to make the capstone presentation of NASA's fiscal year 1987 budget requirements.

One would be hard pressed to recall any Federal agency that faced so many crucial and immediate needs in such a stringent budget environment as NASA does now. The overwhelming magnitude of NASA's fiscal year 1987 budget requirements is almost equalled by the ever-changing and fluid nature of NASA's programs that have been affected by the *Challenger* accident. NASA's budget is in the truest sense a moving target.

Even though NASA may have quantified the severity of some of its accident-related budget requirements, what is most troublesome for this subcommittee and for NASA has to be the number of looming budget requirements that at this point in time are not precisely quantifiable. Restoring the space shuttle to a state of flight readiness has to be our number one technical priority. Yet, the changes to do so will surely cost hundreds of millions of dollars, and the ceiling for these expenditures seems far from within sight.

And as if this were not enough, NASA is also faced with the pending actions of the Senate and House Armed Services Committees and they consider reducing DOD's shuttle reimbursements to NASA by as much as $530 million. Also, with the cancellation of the shuttle-Centaur upper stage program, NASA's budget requirements are further clouded by the uncertainties of which alternative launch options best meet NASA's requirements and resources.

All of this adds up to an alarming national challenge. By all accounts, NASA is faced with the prospects of needing between $8 and $9 billion in fiscal year 1987. In the most austere budget environment we have faced in years, funding NASA becomes one of Congress' most difficult tasks.

Nevertheless, this subcommittee and the parent committee are committed to securing for NASA the maximum funds available within relevant budget constraints.

Regrettably, funding NASA will not complete the job at hand. Also remaining to be resolved are a number of difficulty policy issues, such as the size of the shuttle fleet and its future role, and the nature of our ELV capability.

We have been continuously teased by newspaper accounts that indicate that the Administration is within days of making decisions relating to this and other policy issues. Certainly, these issues are the most complex of any that our space program has ever faced.

Yet, the absence of crisp and timely decisions on these crucial policy issues has only extended and intensified the interagency turf battles that have left NASA and the American public the victims.

Dr. Fletcher, this is not a fair environment in which you have been asked to write NASA's ship. Regrettably, you have probably had more hurdles placed in your path than offers of assistance.

Nevertheless, this subcommittee is anxious to work with you to ensure a smooth and timely recovery of our civilian space program. Over the past 28 years, this nation and the rest of the world have grown accustomed to a continuous record of rich accomplishments from NASA, and there is no reason that we cannot enjoy a similar record in the future if we are willing to give our space program the priority it deserves.

With those thoughts in mind, we welcome you and your colleagues here today. But before we start with you, Senator Riegle.

OPENING STATEMENT BY SENATOR RIEGLE

Senator RIEGLE. Thank you, Mr. Chairman.

Dr. Fletcher, let me welcome you back to the subcommittee. I must say that as we try to follow what is happening with respect to space policy, it has gotten pretty discouraging, I think, certainly for us here in the Congress trying to understand what the policy direction and decisions will be finally from the administration.

And I suspect that it has to be frustrating to be in your shoes these days, to try to sort out the difficulties and figure out where we are going and how we are to get there.

It seems to me that at present we are at the most critical point in the nation's space program that I think we have faced since the program began. With the *Challenger* explosion on the 28th of January, it seems to me that we have gotten very little clear by way of overriding policy direction since that time.

We do not have a clear answer as to whether or not we are going to replace the shuttle, and if so when. We now learn that apparently we are going to get out of the commercial launch business, despite the fact that we have made important commitments to commercial customers and in our thinking about the space program up until now that has been an important component of a balanced concept of a space program.

It now appears that the Defense Department is going to take and move off more on its own. It has a very large space program to begin with, but they apparently wish to expand their program, but at the expense of NASA.

So we see what looks like a further withdrawal of joint effort on their part in NASA. The list goes on.

But we have had certain other major announcements with respect to deletions from the program. It seems to me now that, although many of us here feel strongly that we should proceed with the space station, even that is in some jeopardy because it isn't clear how we take the succession of steps to move from where we are today to the point where we would be in a position to meet the kinds of timetables that we have set for ourselves with the space station.

All this in light of the fact that the Russians, of course, have an operating space station of sorts now. They have cosmonauts that are staying up for very great lengths of time and performing whatever experiments they have under way.

And we are looking at a prospect of not being able to proceed to build and man the space shuttle or a space station until some time well into the 1990's. So we have been looking and waiting for direction from the executive branch as to what is to happen here and what their views are to be.

On one occasion, we had the President saying publicly that he wants another shuttle, and then we have senior aids literally within hours saying that the President in effect doesn't know what he's talking about and we're not going to have another shuttle, or at least not at any time soon.

So I don't know who's making the decisions. In fact, I can't see much sign that decisions are being made or, to the extent that they are, they seem to be made in a very haphazard, piecemeal fashion.

And out of it I do not see any coherent forward strategy to get NASA moving ahead. Now, having said that, I think the Rogers Commission did a very good job of carrying out its mandate to investigate the causes of the *Challenger* accident. It seems to me that the recommendations they have made in terms of safety changes and other internal re-evaluations seem to be under way.

I am not here to find fault in that area. It seems to me that a lot of diligent work is taking place, as it properly should, as the follow-on to the Rogers Commission recommendations.

But I see that as for the most part separate and apart from this larger question of space policy. And it seems to me that in that area we are still in a paralysis that almost reminds me of those terrible moments after the space shuttle exploded and was coming down toward the ocean, with no ability to take and control the events at that time.

It seems to me that in a sense our space program is much like that at that moment. We just seem to be kind of cascading, without any close sense of control and no sense as to when control might be reasserted. This is a widely held view by professionals who care deeply about the space program.

I want to insert in the record an editorial from *Aviation Week and Space Technology*, which is entitled "Who's in Charge?"

[The following information was subsequently received for the record:]

[From Aviation Week & Space Technology, July 28, 1986]

WHO'S IN CHARGE?

The United States is at an historic juncture with its space program and is in critical need of positive action to end the indecision blocking definition of a coherent policy that will reassert the U.S. leadership in space. The trouble is, no champion has stepped forward to seize the initiative, and the ensuing confusion leaves even casual observers wondering whether anyone is in charge of setting the nation's space goals.

President Reagan should be, But a variety of factors, some valid and many not, have prevented concerned space officials from putting their proposals before him. Top White House advisers who have direct access to the President either are too technically unsophisticated to grasp the importance of rekinding an aggresive, well balanced space program, or are preoccupied with other issues they deem to have higher political quotients.

Whatever the reasons, the result has been months of indecisioin that have created an unhealthy environment. The U.S. aerospace industry so far has failed to raise its voice to prompt any public debate and, instead, is waiting for policy guidance before proposing corrective actions. The National Aeronautics and Space Administration has drifted into internecine squabbles that are complicating the shuttle reconstruction effort and threatening the continued viability of the space station program.

NAMING THE PROBLEMS

In contrast to its early heady days, even a partial list of the problems confronting the U.S. space program today makes for dreary reading:

No decision has been made on a fourth replacement orbiter, and that is a national disgrace. Aerospace plants across the country that produced even the smallest pieces of the initial orbiters should be humming 24 hours a day, seven days a week to get a new vehicle built. Jim Fletcher, who was cajoled into taking the NASA helm again, has lobbied for a replacement orbiter with polite memos to the President's Cabinet. He also has exchanged heated words with top White House advisers blocking his efforts to get a decision from President Reagan. But since he was pressured into taking a job he really didn't want in the first place, he ought to be pounding on tables or going public with demands that he be given the tools he needs to complete the task.

The U.S./international space station project has degenerated into turmoil, as NASA headquarters wrestles with the Johnson Space Center, not only who has primary management responsibility but also over the basic scope and direction of the program. NASA headquarters should heed the concerns being raised by Johnson program officials concerning potential problems with the station configuration.

The Air Force has now decided its recently completed shuttle launch complex at Vandenberg, AFB, Calif., should be mothballed for at least six years, in part to avoid putting undue demands on a depleted shuttle fleet. If the American taxpayers, their congressional representatives and the aerospace industry that built and plans to operate that multibillion-dollar launch facility allow it to be cocooned without raising a storm of protest at the colossal waste of resources, then the answer to the question of whether the U.S. has a meaningful commitment to space would appear to be a resounding no.

Basic issues have not been addressed on the development of expendable launch vehicles to assure the U.S. full access to space. Until this is clarified, commercial payload developers, as well as scientists and interplanetary explorers, have little on which to base future plans.

Saying that the U.S. space program is in shambles overstates the case, but not by much. Constructive action has been taken in the six months since the shuttle Challenger accident. The Rogers commission has issued its report verifying the root causes of the accident and recommending a range of corrective actions.

NEED TO MOVE ON

And yet, a malaise pervades the U.S. space program. The country has gone through an agonizing period, experiencing the catharsis of public investigation and blame fixing. What is needed now is some strong restorative medicine—a clarion call for the U.S. to pull up its socks and get on with the job. What one sees instead is continued indecision and a conservatively paced, if not stodgy, shuttle recovery program that has pushed the restart of flight operations out to February, 1988.

It would be irresponsible to diminish the importance of thoroughly reviewing the shuttle design and reworking the technical weak points before clearing the next shuttle for flight. Taking a kick-the-tires, light-the-fires and launch approach could run the shuttle program pell mell into another accident that would kill it. But moving along at a sedentary pace with no clear sense of where the shuttle program is headed or what role it should play in the U.S.'s future space plans will bring on a hardening of the arteries that will prove just as fatal.

Where is the sense of urgency in the manned space-flight community which should be clamoring for a fast paced recovery effort? The National Academy of Sciences' space science board has jumped into the fray on the other side with a campaign to corner a bigger share of the NASA budget to replace space sciences monies it feels were siphoned off to fund the shuttle program. NASA's once-proud space science and interplanetary program plans have all but atrophied and the charter to explore the outer regions of our solar systems and beyond has passed to the Soviet Union by default. There is a risk this debate may overlook a key point, which is that a strong manned space flight and a strong scientific and planetary space program are not mutually exclusive. The U.S. can fund both. The fact that it does not reflects a lack of leadership and initiative, not resources.

When the dozens of related issues are added to the list of problems in the U.S. space program, it leaves an overwhelming impression of how much remains unresolved. The question is, does anyone really care? Is any one exercised enough about the danger this represents to raise the alarm, to join the debate, to offer solutions, to demand action? —DONALD E. FINK, Washington

Senator RIEGLE. You may well have read it. Just to summarize it, the article states dramatically the massive problems facing the space program: Vandenberg, the space station management difficulties, the issue of expendable launch vehicles.

And in conclusion, that very important editorial said this: "When the dozens of related issues are added to the list of problems in the U.S. space program, it leaves the overwhelming impression of how much remains unresolved." Continuing, they said: "The question is does anyone really care? Is anyone exercised enough about the danger this represents to raise the alarm, to join the debate, to offer solutions, to demand action?"

I think that states it exactly as it is. It captures the frustration that I feel because, try as we might to push this policy process forward in terms of the overriding decisions, policy decisions that have to be made, it seems to me that we are really not moving.

We seem to be, as I said, in a form of paralysis. Now, I have suggested as one way to change this and have introduced legislation to reestablish the National Space Council, which would be headed by the Vice President, to give this policy making function more structure.

The purpose of the council, which of course in the past served as a vital element in the Apollo program, which was very successful, would be to get the space program off dead center and back on some kind of meaningful track.

But I think the longer we wait and in a sense drift, the further behind we fall to the Europeans, the Soviets, and others around the world. And after spending 20 years in the forefront of the space exploration area on a worldwide basis, it seems to me we are now in a sense ceding part of that role to others and allowing ourselves to begin to index backward into a different kind of status.

I find that unacceptable. I think it is unwise. I do not think it is in the strategic interests of the country. I do not think it is necessary.

I think it is the result of bad policy coordination at the top, failure or an inability to make decisions. And frankly, I do not understand it.

Try as I might to resolve these conflicts in what we hear from top people in the administration, there does not seem to be any way to resolve these conflicts. Out of it, we are failing to get the kind of clear policy direction that we need.

Now, I want to just say that I understand the chairman of the subcommittee has included the space council concept in the authorization bill which is to be marked up on Thursday, and I am appreciative of that fact and I think that is a forward step.

And it may be one of the useful ways in which we can put a decision structure with some clear responsibility around this process, so that we can start to get some orderly decisions.

But he has also mentioned the problem of the budget strains that we face. The chairman and I both serve together on the Budget Committee and we are acutely aware of the problems that we are facing there, particularly as Gramm-Rudman now begins to squeeze in on all spending.

And as we look now just at the premium costs associated with the aftermath of the investigation of the accident, the whole process of coming in now and making the kinds of mechanical and organizational fixes that are required and obvious, that we are probably looking at costs there, even if we set aside the issue of a replacement, we are probably looking at costs that are upwards of a billion dollars just to work our way through those difficulties.

And as I say, if we are going to go ahead with the additional shuttle, which I still feel is justified, although I am prepared to listen to arguments on the other side, but it seems to me that it is, in light of our future plans with the space station and other things. There is no answer as to how this money is to be forthcoming.

There is a proposal to go and raid the cash box at Conrail. I happen to think that is a mistake and I do not think that is going to work, so I do not favor that. I think it sidesteps the issue.

There are other people who now want, in effect, to change the rules of the game and pull out other funding sources that NASA has depended upon, particularly now the joint venture activities with the Defense Department. And I see NASA being harmed by, if you will, additional damaging circumstances beyond the accident, at a time when everybody ought to be coming together, I think, to try to put things back together and try to compensate for the effects of the accident.

So that is where we find ourselves at the present time. I will just make this further observation. I know when we spoke, when you and I spoke after your nomination to this job, you had indicated that you had given some considerable thought as to whether you would come back in or not at this point, and you were persuaded to do so because of your great devotion to the space program, your past history, the personal appeal of the President, the extraordinary needs of the time, and so forth.

You agreed to come in. Now you are in this position. I must say that as I try to imagine what it is like to be in your shoes these days, that I can imagine it is a tremendously frustrating experience to be there in an extreme condition of difficulty, and to want to try to move to fix it and to take the steps, and then to find that the key decisions that have to be made, the policy decisions and then from that the budgetary support, just do not seem to be forthcoming.

The weeks go by, the months go by, and we are not getting clear signals. I do not know how we function that way, frankly, and I hope today that you will be frank about it and tell us where we are, because I do not want anybody misled. I do not want the public misled.

I do not want the people in the astronaut corps or the others that work in NASA or who have come through this difficult period misled. I think they deserve straight answers in some sense as to how we are going to take and reintroduce some kind of orderly process forward into what seems to be a kind of paralysis and confusion at the policy level that we see at the present time.

So I am going to ask you some pointed questions about it, but I hope you will volunteer at the outset some very clear thoughts on this so that we can understand where we are starting from.

Senator GORTON. Senator Trible.

OPENING STATEMENT BY SENATOR TRIBLE

Senator TRIBLE. And let me say, Mr. Chairman, that I look forward to working with you in shaping a NASA program that makes sense and that meets our national interests. Surely the time for us to move ahead is here.

It is an important task. It will call for us to work together. And I would hope that we could avoid confrontation which has so marked this dialogue for the last several months, and that we could find a consensus on which we can build and develop a meaningful, positive, forward-looking program.

Senator GORTON. Senator Gore.

OPENING STATEMENT BY SENATOR GORE

Senator GORE. Thank you, Mr. Chairman. I have a brief opening statement.

If you look at the budget request that has been submitted to this committee and if you read nothing else about the space program for the last year, you would come to the conclusion from this budget request that the last year had been kind of a routine year, that nothing unusual had happened; with business as usual, nothing extraordinary in the way of effort or new initiative needed, just plodding right along as if nothing had happened.

But of course, it has not been a routine year for NASA. And it strikes me that there is such a dramatic contrast between the President's moving words after the *Challenger* tragedy, and one of the most magnificent speeches I have ever heard a President make—and if you laid that speech along side the budget request, it just presents a really striking contrast.

We are clearly at a crossroads because of the great tragedy of the loss of the *Challenger* and three of our expendable launch vehicles have failed. The Rogers Commission has presented us with a portrait of a space agency with fundamental structural and management flaws to correct, and as a result it is clear we have to move forward with something more than business as usual.

I hope we can all agree that one of the best elements of any program for rehabilitating NASA should be realism. If we don't look our problems squarely in the eye, we can't begin to make the critical choices that lay before us.

Therefore, I fail to see how we can formulate a budget in the manner in which we are asked to do it. First of all, we have been waiting for months and months for leadership from the White House and for guidance from the White House with respect to their priorities down there.

And yet, these many months after the *Challenger* tragedy we still have no idea what their basic thoughts are, what their thoughts are, that is, on such basic issues as whether or not we should proceed with a fourth orbiter. And yet, we are asked to embark on a plan for next year anyway, taking the approach of business as usual.

Well, the budget before us is one that we know is inadequate. The money which the chairman is seeking to add from the transfer of Conrail funds won't even cover the shortfall created by the military if it withdraws its reimbursements for fiscal year 1987.

The budget does not appear to have money for such items as implementing the Rogers Commission recommendations, not to mention buying ELV's, switching planetary missions to ELV's, and a host of other important and expensive tasks which remain to be performed in the wake of the unusual events of the last 6 months.

None of us wishes to increase budgets, but we must be realistic. It is simply not responsible for us to consider a budget essentially unchanged from the budget submitted before the *Challenger* disaster. Some things have happened, let us face it.

It is not responsible for us to simply vote a budget that we know has shortfalls and then expect to pick it up with a supplemental later on. That is simply a case of putting off our pressing decisions, and the space program and the country deserve better than that.

If we face this crisis with realism and candor, I believe we do have a chance to restore the space program to its previous levels of excellence. Therefore, I will be particularly interested to hear the responses of Dr. Fletcher this morning.

If we can work with the Administration in a straightforward manner, identify our problems, and make the crucial decisions, we can prevail over the current crisis. But if the Administration continues to delay and we continue to vote out budgets as though nothing at all has happened over the past six months, then we are making bad public policy and jeopardizing one of our national treasures.

Finally, in conclusion let me say, Dr. Fletcher, that in the past, in spite of your overwhelming confirmation here, I was critical of you. I want to make it clear on this occasion that I do not seek to lay the responsibility for this course of events that I have just described at your doorstep.

This is at the doorstep of the White House. There is a vacuum of leadership, a failure to recognize the key decisions that have to be made, and a failure to make those decisions.

We need candor from you. We need realism, and I trust we shall get it this morning.

Thank you, Mr. Chairman.

Senator GORTON. Senator Rockefeller.

OPENING STATEMENT BY SENATOR ROCKEFELLER

Senator ROCKEFELLER. Thank you, Mr. Chairman.

I apologize for being late, but we had a concurrent energy hearing on coal exports, which is a matter of some importance to the state of West Virginia.

Mr. Chairman, I welcome very much this chance for the Commerce Committee to look at NASA's budget for the coming year. There is no question that we are still recovering from the full ramifications of the *Challenger* disaster.

The budgetary consequences of the accident, as well as the 2-year grounding of the shuttle, are clearly enormous. Virtually the entire NASA budget is affected in some way by the accident and by its aftermath.

In my view, Mr. Chairman, it is essential for us as the authorizing committee for the space program to make a thorough and realistic assessment of NASA's needs in light of these developments and then to act on them according to what we think should be done.

I agree with Senator Gore, there has not been leadership from the White House with respect to the budget. We are waiting months and months and months and there is nothing. I know of no other program where this is so true.

We hear from parts of the White House that there shall not be a fourth orbiter. We hear from others that there might be. And the budget, which is the instrument of governance in this country, reflects no priorities and virtually no interest.

I am dismayed, I must say on behalf of our part, Mr. Chairman, to learn that the subcommittee at least has been planning and may again be planning to return to a proposal to tap some of Conrail's assets. Conrail being a railroad, which has very little to do with the space program, which has some money which is called government money, which they need in order to operate, in order to market themselves to become private.

So we as a committee have been looking at Conrail, a railroad's assets, as a source of additional funding for the space program. All together, including $460 million from Conrail should this committee make the mistake of voting that, this proposal amounts to only $7.8 billion for NASA, which is, coincidentally, about the same as the Administration's original budget request drawn up before the space accident.

It is not a number which adequately reflects in my judgment the changed circumstances facing NASA, facing Dr. Fletcher as its Administrator, and the support that we need to be giving him in his program.

Meanwhile, on the other side the proposal to take cash from Conrail is a seriously flawed one. I have argued in this committee, Mr. Chairman, that we would be undermining the financial position of the railroad and hurting our chances of selling it for the sake of a budgetary gimmick.

In fact, at our last session on this I suggested that if we really want to help NASA, don't just take some cash which prevents the railroad from operating on a year to year basis, but let us work toward the sale of the railroad to the private sector, keep competition up, and take all of that money, by that time perhaps $1.9 billion, and give it to NASA.

Now, maybe that is a budgetary gimmick, since that would be a one-year infusion of cash. But if we are going to gimmick, let's at least do gimmicking at a suitable level.

But I have to say, Mr. Chairman, as I have said to you before, Conrail is a railroad. It is an independent railroad as between the two majors, and it is vital to communities in my state of West Virginia, throughout the Northeast, and throughout the Midwest of this country. It employs 33,000 workers.

Now, sale of Conrail is a possibility, bringing in up to a couple of billion dollars or more. But we should not destroy competition. We should not destroy essential rail service for the purpose of trying to come up with more money for NASA.

If we want to come up with more money for NASA which we need, let us do it. We are the authorizing committee. We have the power to recommend that. Then it is up to Appropriations to make good on that. We can work with them.

But let us not deal in flights of fancy. Let us deal in real solid money for Dr. Fletcher and NASA. It is our job, I repeat, as the authorizing committee to decide what the course of the civilian space program should be.

I am not so sure how on top of the entire situation this committee was in its oversight function throughout the last numbers of years. Well, here we have a chance to establish budgetary dominance on this matter, to initiate what we think NASA should have to regain the place that the American people want to see it have, and then authorize that amount of money, Mr. Chairman.

It is not a matter of trying to hit an arbitrary budget target, particularly one that was not derived by taking stock of the implications of the *Challenger* accident.

The space agency has been through some very, very tough times, and now is the time that Dr. Fletcher and his agency need our support, budget support, not speeches, not gimmicks, but budget support.

I believe the gains to our society from space exploration are enormous, and if there is any time that we should not send the wrong signals to NASA or to anybody else in this country, to young people, to scientists, to people trying to push math and science and to keep the horizons of our country vibrant, this is not the time to cut back or gimmick on NASA.

I would hope that any authorization this committee puts forward would reflect our true beliefs about the value of space exploration and of NASA.

I thank the chairman.

Senator GORTON. Dr. Fletcher, we welcome you here today and we will be delighted to hear your statement.

STATEMENT OF HON. JAMES C. FLETCHER, ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION; ACCOMPANIED BY THOMAS L. MOSER, DEPUTY ASSOCIATE ADMINISTRATOR OF SPACE FLIGHT; AND C. THOMAS NEWMAN, COMPTROLLER

Dr. FLETCHER. Mr. Chairman, first of all, I would like to introduce Mr. Tom Moser, who is Deputy Associate Administrator for Space Flight. He is deputy to Admiral Truly, who was not able to be here this morning.

Second, Mr. Chairman, I would like to submit my statement for the record.

Senator GORTON. It will be included in the record in full.

Dr. FLETCHER. Thank you, sir.

And also with your further permission, I would like to take this opportunity to make some what I think are important points with regard to the space program and address some of the things that you all are concerned with. This would deviate somewhat from my statement, but I would like to do it, Mr. Chairman.

Senator GORTON. That will be all the more important for us, since we already have your statement.

Dr. FLETCHER. Well, as you all have indicated, this is a crucial budget for NASA, at a very crucial time in its history.

I agree with most of what was said this morning. We are doing our best to present the best possible budget that we can with the uncertainties that we are now facing. What I would like to do is to start with the high road first, Mr. Chairman, and talk about some of the things that have happened since the accident and since I have been aboard, almost three months, or not quite three months yet, and then ask Mr. Tommy Newman to address some of the highlights of the budgetary questions that you have been asking about.

First of all, looking at the progress toward recovery, we are busily at work at NASA, Mr. Moser and his associates, trying to fix the shuttle and to return to flight. We are making good progress in that direction, as was mentioned by Senator Riegle.

We have established a new office of safety, reliability, and quality assurance, and George Rodney will start next Monday in that capacity. Actually, he is on board this week informally, but will start officially next Monday. And he will do a lot toward fixing our safety, reliability, and quality assurance program, as was suggested by the Rogers Commission.

We are also busily redesigning what we call the SRB, the solid rocket booster, joint which was a cause of the accident, and we have a planned test program which will lead to the target date of restoration to flight in the first quarter of 1988.

We have established a committee to review all of NASA programs and how they are managed, under General Sam Philips, who was the program manager for the Apollo program. He is busily reviewing the entire NASA program.

Also, Capt. Bob Crippen is making a review of the space shuttle program management structure itself and is looking at all the communications procedures and so forth related to the space shuttle program.

We are about to announce a new director for the Kennedy Space Center, hopefully by the end of this week or at least early next week. We are not quite ready for that.

But I am ready to announce today the appointment of Mr. J. R. Thompson as director of the Marshall Space Flight Center. Mr. Thompson served 25 years with the Marshall Space Flight Center and was in charge of the recovery operations in Florida after the accident.

He has agreed to come back from Princeton University, where he has been for the last three years, and serve as the director of the Marshall Space Flight Center, probably in September.

I might add at the same time that we are in the process of reorganizing our external affairs operation. We have brought Astronaut Rick Hauck, whom some of you know, back to Washington to serve as deputy director of external affairs, and he will be starting today.

That is not a public announcement, but for your information he will be coming around to visit you and give you some idea of the feeling down in the astronaut group, and will be a deputy in charge of external affairs for NASA.

We also have established a shuttle safety review, which includes all aspects of the shuttle program from operation from launch to landing, the procedures involved and how we make decisions, both just before launch and during the weeks and months before launch.

The budget request supports that balanced and multifaceted program in space and aeronautics and proposes revisions, albeit uncertain because of the impact of the accident on the program.

With regard to the space station, it continues to move ahead. The fiscal year 1987 budget initiates vitally important aspects of that development. For example, the management realignment that is planned to improve the efficiency and accountability has started.

We have agreed to a 90 day review of the program, during which we will consult closely with Congress on the projected impact of any changes, including possible design changes which are geared for greater astronaut safety.

Our goal is still to start development of the space station in 1987 and to have the space station operating by 1994, as the President directed. I see no change in that goal.

But we do need the fourth orbiter to keep the program on track, and we need supplemental funding to pay for it. We are not prepared to discuss supplemental funding today because the decision, as you know, as you have mentioned, is still pending. But we want to emphasize that the space station cannot be built on time without that replacement orbiter.

We are involved still with our international partners on the space station, which is an important part of what we are doing on the space station. It is an international space station.

We are delighted that we have agreement with all the partners on the hardware elements for the preliminary design of that space station, and have started negotiating with those partners the long term operations of the various space station elements.

The budget request will signal to them that the U.S. industry—and to the Soviets, by the way—that our commitment to U.S. leadership in space is still strong and unflagging.

Moving on away from the space station, I do agree with your point that the Soviet MIR, the M-I-R, does represent an important step forward for them in space capabilities and it demonstrates a sustained national commitment to long term goals in space.

We do indeed need the same kind of commitment if we are to prepare for the space station era and all its potential benefits and to maintain U.S. leadership through the 1990's and beyond.

As you indicated, we cannot afford a stop-start operation for space station and cannot afford it for the shuttle, either. Changes to budget reflect about $800 million in savings because we are not flying, savings to be applied to other requirements.

The budget request also assumes necessary reimbursement, as you mentioned, of $531 million from DOD to keep the shuttle program going while we are preparing to fly again. This is money that is owed to us by the Defense Department, part of which we have spent.

Mr. Chairman, the American space program is too important to science, to commerce, to industry, for economic progress and for national security to let it falter. With your help, together we will sustain and rebuild it and retain U.S. leadership in space.

Now, with your permission, I would like to ask Tommy Newman to fill in some of the highlights of the budget request.

[The statement follows:]

STATEMENT OF HON. JAMES C. FLETCHER ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. Chairman and distinguished Members of the Subcommittee: I am pleased to appear before you today to present President Reagan's FY 1987 budget request for NASA which was transmitted to the Congress on February 5, 1986, and to discuss revisions which we think will be necessary as a result of the Challenger accident. The pending NASA FY 1987 request is for $7.7 billion, of which $3.0 billion is for Research and Development, $3.1 billion for Space Flight, Control and Data Communications, $181 million for Construction of Facilities, and $1.4 billion for Research and Program Management.

The loss of the Challenger obviously will affect many aspects of the budget request before you, but you may be assured that a majority of the program presented in the President's budget remains valid and we are prepared to discuss the impacts of the accident on the program.

The United States remains committed to the development of a permanently manned Space Station, and the budget request before you reflects this commitment. Recognizing that the Space Station is essential to ensuring American leadership in space during the 1990's and beyond, President Reagan has continued to reaffirm his support, most recently in his 1986 State of the Union address. In the decades ahead, the Space Station--still our next logical step--will enable us to continue the exploration and utilization of space, an enterprise in which the United States traditionally has excelled. The Space Station will represent a new level of capability in space; it will be a permanently manned facility for science, commerce and technology.

The FY 1987 budget request initiates development of the Space Station, an event that is extremely important. It will signal to our international partners that the U.S. commitment to the Space Station is firm and that their own budgetary and intellectual resources can safely and productively be devoted to a cooperative Space Station Program. It will signal the private sector here in the United States that future investments in commercial space activities can be planned with confidence. It will signal to U.S. industry that the Space Station Program is on track and that its own investment of money and talent is justified. In addition, moving forward as planned will signal the Soviets, who now have an operational Space Station, that their current advantage will not remain unchallenged. Perhaps most importantly, proceeding with Space Station development in FY 1987 strengthens the commitment to U.S. leadership in space in the 1990's and beyond and signals America's intention to look confidently to the future.

A major feature in the science and applications portion of the FY 1987 budget request is the initiation of the Topex flight program. This ocean topography experiment, which is being conducted in conjunction with France, will provide information leading to an understanding of the world's oceans far exceeding anything known in the past. The fact that 85 percent of the Earth is covered by oceans and that much of this area is far from normal shipping lanes or aircraft overflights has prevented the ocean science community from effectively addressing the question of ocean circulation on a global basis. We anticipate that Topex will result in a greatly expanded understanding of how our ocean systems work. This will be of great benefit to both the ocean science community and to users of ocean data such as shippers, fisherman, and others dependent on the ocean as a source of resources or income.

A series of already-approved space science and applications flight projects are progressing toward flight readiness. While the launch dates of these projects are obviously delayed by the Challenger accident, their objectives and their importance to the expansion of human knowledge remain unaffected. When we resume space launches, the Hubble Space Telescope, which will provide a quantum jump in our ability to observe the universe; Galileo, which will probe the giant planet Jupiter; and Ulysses, the ESA-developed mission to probe the polar areas of our Sun, will be ready for launch. Other space science and applications missions included in this budget are the Gamma-Ray Observatory; Megellan, a mission to map the planet Venus; the Mars Observer; the Upper Atmospheric Research Satellite; and the scatterometer sensor for the Navy's Remote Ocean Sensing System (N-ROSS). In the field of solar terrestrial physics, we are proposing a program which will allow us to participate as experimenters in a comprehensive international research program.

The budget includes a continuing substantial and very productive program of research and analysis in areas ranging from physics and astronomy, to life sciences, to geodynamics, to upper atmospheric research and many other areas. The most striking product of this program in recent months has been the highly successful and exciting Voyager spacecraft encounter with the planet Uranus. Some of the important new findings include fundamental scientific discoveries about the planet Uranus and its rotation, magnetic field, atmospheric structure, rings and satellites. Observations of the innermost moon, Miranda, show perhaps the geologically most unique moon yet encountered in the solar system.

The budget request also provides for the important continued investment in advanced space technology. In the space research and technology program, increased emphasis is planned for automation and robotics research to enhance the productive and effective use of space and on transportation technology for low cost access to and from space and between orbits.

In his State of the Union address to Congress this year the President referred to research underway on a joint NASA/DOD National Aerospace Plane Program. The aerospace plane is a vehicle, part aircraft, part spacecraft, which could fly from the Earth through the atmosphere into space and back. A significant initiative in the NASA budget involves focused research on aerospace plane technology and is a direct outgrowth of advances and breakthroughs made during the past decade in NASA's ongoing aeronautics and space research and technology base programs. The critical elements of the program will include airbreathing propulsion systems that can operate from take off to near orbital speeds, reusable efficient thermal structures, and integration of the propulsion system and airframe for a minimum weight system with good performance throughout a broad range of acceleration, cruise, and maneuvering flight conditions. Advances in many of these technologies will be applicable to both airbreathing and rocket powered vehicles, thereby further increasing the potential payoff to all future space transportation systems. The technology development in this next phase of the program will provide the basis for a future decision to proceed with the experimental vehicle phase of the program.

During this past year, the White House Office of Science and Technology Policy announced the establishment of National Aeronautical R&D Goals designed to focus U.S. research and development in high pay-off technology areas that will sustain the Nation's aeronautical preeminence into the 21st Century. Our program of aeronautics research and technology is proceeding to meet these goals by providing the cutting-edge technology for future aircraft. As an example, the advance turboprop propulsion system, which is receiving increasing industry attention and support, will be flown early in FY 1987 and may soon lead to a whole new generation of fuel efficient transports. Just last week the Numerical Aerodynamic Simulation (NAS) facility reached operational status. NAS is the most powerful computing system in the world and a national resource for computational solutions to complex fluid flow and structural problems encountered in advanced vehicle concepts. Now let me turn to the impact of the Challenger accident on our funding plans for FY 1986 and FY 1987. In brief, these impacts include:

—reduction in near-term funding requirements for planned flight activities, for payload and mission preparation and related supporting activities. The net reduction in NASA funding for shuttle operations reflects savings inoperational costs partially offset by loss of expected reimbursements from foreign and commercial users of shuttle;

—redirection of some effort previously planned for operation of major missions such as Space Telescope and Galileo into sustaining activities in preparation for revised mission activities when shuttle flight operations are resumed;

—procurement of a Tracking and Data Relay Satellite (TDRS) spacecraft to replace the TDRS which was destroyed;

—continued operation of tracking ground stations which had been planned for closing;

—delaying the planned main propulsion system ground test pending further examination of the technical issues involved in that testing;

—accident investigation requirements, including salvage operations;

—undertaking corrective actions, identified by the Rogers Commission and ongoing investigations, such as working with the National Research Council independent oversight group on the solid rocket boosters. The solid rocket motor field joints are being redesigned, hardware modifications will be made and testing of the modified motors conducted; and

—termination of the Shuttle Centaur upper stage program. We are studying alternate methods for launching the planetary missions including other upper stages from the Shuttle or using ELV's.

The FY 1986 Operating Plan for the original appropriation level totalled $7.656 billion. Under the Deficit Control Act sequestration process we have taken a reduction of $323 million for a revised FY 1986 plan of $7.333 billion.

We have sent you a revised operating plan for FY 1986 which has been approved. In that plan, we identified $147 million in offsets primarily from reduced operations costs which have been applied against increased funding requirements for science and applications programs, tracking and data, lost reimbursements and anomaly resolution.

In FY 1987 we have tentatively identified approximately $800 million of offsets to cover extension of development and ground activity for a number of spacecraft projects, loss of Shuttle reimbursements, initial funding for replacement of the Tracking and Data Relay Satellite lost in the accident, cancellation of the Shuttle Centaur and initial funding for replacement upper stages, continued operation of the tracking ground stations, the cost of sustaining the necessary contractor teams on affected projects. We also ekpect to achieve a net savings available for the additional requirements in the space transportation area. At this time, these adjustments do not provide funding for major hardware changes which may be determined to be necessary from the Rogers Commission and ongoing investigations. They also assume we will receive $531 million in shuttle reimbursements from the DOD. Based upon anticipated recommendations from the Rogers Commission and our best assessment of the time needed to make the modifications to the solid rocket booster motors and other hardware or procedural changes, the next shuttle flight is planned for the the first quarter of calendar year 1988. Mr. Chairman, as you know, there is an ongoing interagency process to examine options and issues relating to the Challenger accident and how best to fund and implement the changes necessary. I am confident that we will correct the causes of the Challenger accident and the shuttle will emerge as a stronger, safer system capable of meeting space launch needs for years to come. The introspection that NASA is undergoing as a result of this accident investigation will make NASA a stronger agency committed to innovation and technical excellence that will retain American preeminence in space into the next century. Space has been, and with the shuttle, our science activities and the Space Station, it will continue to be, an American frontier. Mr. Chairman, this completes my prepared statement. I would be pleased to respond to questions you and other Members of the Subcommittee may have.

Senator GORTON. Mr. Newman.

Mr. NEWMAN. Mr. Chairman, the budget request that we submitted in January that Senator Gore referred to was a request for $7.7 billion. Of that amount, about $3 billion was for research and development, $3.1 billion for the account called space flight, control and data communications, which includes the shuttle operations, the shuttle production activities, and the tracking and data operation.

We had $181 million for construction of facilities and $1.4 billion for operation of NASA's installations, including all of civil service salaries.

Now, in that budget we did assume that the Department of Defense would provide reimbursements of $531 million for shuttle missions, as planned and consistent with our agreements. And we also assumed that we would get $173 million of reimbursement from foreign commercial customers for shuttle missions.

Now, as Dr. Fletcher said, since that time we have been working to adjust the budget for both the savings that could be realized as a result of the change of plans on the shuttle and to add in the things that we need to do to recover from that accident.

The savings that we identified were about $800 million. A little over $500 million of that was from the decrease of shuttle operations. The balance involved a number of things: delay of science programs, the change in planning on stages—well, it involved the delay of science programs, delay of the space lab missions, delay of the orbital maneuvering vehicle, a number of actions we could take related to missions that were delayed.

We had a series of increases, including those required in relation to the upper stages, cost of changing plans on some major science missions. And those increases, if you do not count the changes in shuttle, total about $380 million. They included also replacing the tracking and data relay satellite.

That left us with about $400 million available to apply to problems in the shuttle. We had, however, a loss of reimbursements from the foreign and commercial sector. That would account for about $350 million.

We looked at the requirements of the Rogers' Commission actions and the requirements for anomaly resolution, which are really to fix the SRB and to solve problems in the orbiter and the other elements of the shuttle.

Our estimate for the combined requirements for those in fiscal year 1987 is about $565 million. If you put those figures together, the total requirement then goes up to about $8.2 billion as opposed to the original budget that we submitted of $7.7 billion.

The Congress in this session, but with regard to fiscal year 1986, did provide a supplemental appropriation, you will remember, of $526 million. Well, it was actually $531 million, but $526 million of that was applicable to the shuttle and $5 million was to be applied to automation and robotics.

We believe that we will apply approximately $100 million of that to anomaly resolution activities in fiscal year 1986 and approximately $400 million will remain available in fiscal year 1987.

So to cover the $8.2 billion, we would have that $400 million and we would require new appropriations of about $7.8 billion, provided we receive the reimbursements from the Department of Defense. Now, if we do not receive those reimbursements we would require about $8.3 billion.

All of this is based on our best assessment of where we are now, assuming that the launches resumed in early 1988 and that their estimates on the actions for the fixing of the problems on the solid rocket booster and the other actions recommended by the Rogers Commission, assuming that the estimates for those are reasonably accurate, and of course we are still working on those estimates.

So the requirement in total would be about $8.2 billion if we receive the reimbursements, but that would include the money already approved which enabled us to get started with the anomaly resolution. If we do not receive the DOD reimbursements, then requirements would be a total of about $8.7 billion, of which we have the $400 million from last year's appropriation.

Now, we have not submitted this formally because we have still been working on it, as it still is involved in the issues being decided in the Administration.

That is my summary of our situation.

Dr. FLETCHER. That concludes our statement, Mr. Chairman.

Senator GORTON. Thank you.

Dr. Fletcher, you are well aware of the fact that in its budget resolution for fiscal year 1987, the Congress allocated $7.3 billion for NASA. I think just as citizens you are also aware of the fact that if the budget resolution is enforced to its fullest, we are unlikely to be able to meet the deficit reduction goals of the Gramm-Rudman-Hollings bill. As a consequence, finding more than $7.3 billion for NASA is not going to be easy.

In their opening statements, three of my colleagues talked about the necessity to do so and to fund NASA appropriately, statements with which I fully agree. I just do not know where we are going to find the money and, given the nature of the fiscal challenges over the next year, whatever we say here, unless we come up with some extraordinary source, we are going to end up with $7.3 billion for NASA.

I think I would like your comments right now on the impart of an appropriation of $7.3 billion to NASA. And I really have to ask you for that under two heads, because there is half a billion dollars in addition to that over which we have little control, the DOD reimbursements. What are you going to do?

What priorities will you set at $7.3 billion if you get DOD reimbursements? What will you do and what priorities will you set at $7.3 billion if you do not get DOD reimbursements?

Dr. FLETCHER. Mr. Chairman, as you all properly indicated, NASA is at a very crucial time in its history. And in my opinion, I think well expressed by members of your subcommittee, NASA is too important an agency to let go down the drain, so to speak.

I think it is absolutely necessary that we get adequate funding to recover from the accident and then go on, with some delay, with the space program. The space program is a national asset.

We have had an accident which is a tragedy, but we are recovering from the accident, and we are doing our best and we hope to fly again a year and a half from now. And we are well on the way to do that.

I do not think now is the time to be fussing about budget, although I realize there are severe problems. And I am not a magician to produce that money, but I would hope that the Senate would do whatever is required to find enough money to get NASA back on track. And I support what has been said in that regard this morning.

Senator GORTON. Dr. Fletcher, that is a wonderful statement, but it really does not answer my question.

Dr. FLETCHER. I honestly do not know what we can do. If we start losing funding for the space program, we will simply have to cancel some things. And one of the things that is certain is we will have to slow down the recovery from the anomaly and delay the flight as we restart again.

Senator GORTON. And I suppose either significantly defer certain activities or eliminate essentially all of your new starts?

Dr. FLETCHER. I would guess that would be the least that would happen if we do not get something like the full budget. It would be devastating, that is all I could say at this point.

Senator GORTON. To what extent have you been negotiating with the Department of Defense with respect to its reimburseable payments, then? What is the attitude you get from the Department of Defense on that subject?

Dr. FLETCHER. Well, the Department of Defense know that they owe us that money and they are fully supportive of that position. It was not the Department of Defense that took the money out of the defense appropriations bill. It was a group of your body, Mr. Chairman, that did that.

Senator GORTON. Both bodies, was it not?

Dr. FLETCHER. I think it is not yet finished in the House. I may be wrong on that, but nevertheless it could very well happen in the House as well.

Whatever is the case, the Department of Defense and the Secretary of the Air Force both support our position, that they indeed owe us that money and that they are counting on that money to survive.

Senator GORTON. Do they support that position even at the level which the Congress voted in the budget resolution for national defense overall? They have not conditioned that support, have they, on getting something over and above what the budget resolution called for?

Dr. FLETCHER. Mr. Chairman, not to my knowledge. Pete Aldridge, Secretary of the Air Force, and I both sent a letter reaffirming the Air Force's position on that money, and I think that is fully supported by the Secretary of Defense, and there were no conditions in that letter.

Senator GORTON. That has to be encouraging. In other words, the Air Force agrees that NASA priorities are high enough or that Defense agrees that they are high enough so that even to the extent that they have to suffer cuts, they want them elsewhere, I gather.

Dr. FLETCHER. Mr. Chairman, I am sure that is true. The Secretary of Defense and the Secretary of the Air Force both support getting NASA back on track. They both support the replacement orbiter, and they want to get ahead with the space program.

Senator GORTON. Senator Riegle.

Senator RIEGLE. Dr. Fletcher, you may have noticed in this morning's New York Times a front page story that indicates that the because deficits have continued to grow, and that now the latest estimate by the Budget Office and CBO is that the deficit for this year is likely to be $224 billion, which would be the highest that we have ever had.

It also means two things: One, that Gramm-Rudman-Hollings, which was supposed to mandate a much lower deficit figure for this year, roughly $172 billion for the fiscal year we are now in, obviously is not working, because $224 billion is not $172 billion.

And more than that, it indicates that we are likely to be faced with the automatic cutting mechanism, to the extent that it is made to work, a little bit later in the year. So that even if you get an appropriation here of whatever level, you face the prospect that you are likely to see another automatic cut here before long, simply because of the nature and way that automatic cutting mechanism works.

So if you have not seen that story, I want to draw your attention to it, because it compounds all of our difficulties here. It is just one more blow, if you will, to NASA at a time when it is in deep trouble.

Now, you used the word "devastating" to describe what the effect would be if the money that you need is not made available, if the DOD reimbursement is not allowed, and if the other money that is needed to go in and repair the accident damage and so forth.

Your view was without that money, which you have been planning on, the effect at NASA would be devastating.

Dr. FLETCHER. That is correct, Senator Riegle. If I could just comment further, but maybe I will just be repeating myself, I think the space program is too important to be diddling with too much.

We really have to have enough money to get back on track. When I say devastating, I think it can have serious long range impacts on not just NASA's future, but the country's future in this area.

Senator RIEGLE. Now, if we had that kind of effect—and that is the track we are on at the moment, unfortunately, because we have not had any request from the Administration to put the money in that you say is needed at a minimum.

If we were to have that devastating impact, in my own mind it seems to me, having had the accident, the terrible accident and the loss of the astronauts was one kind of devastating event. And it seems to me in a sense that if we now have a deliberate decision to not allow NASA to repair itself, it is another kind of devastating event.

In other words, it is like having a self-imposed accident, if you will.

Dr. FLETCHER. That is quite right, Senator Riegle. But maybe I am looking at the world improperly, but I look at any supplemental or addition to the funds that are required as a kind of insurance policy.

NASA does not have its own insurance. The government insures orbiters. And basically what we need is an additional amount of money to recover from an accident as an insurance policy.

Unfortunately, the Gramm-Rudman-Hollings Act did not allow for any insurance money, and I think this body needs to address that problem. You vote the money and we have to accept what you vote.

All I am saying is that we cannot recover without adequate funds.

Senator RIEGLE. Well, I think you are exactly right. The problem is who leads the process? Normally the executive branch would formulate an overall policy, particularly in an area as complicated as space, where you have the interrelationship with the Defense Department and you have these international dimensions and the obvious competition that we find ourselves in with the Russians and so forth.

Normally, the Administration would come forward with a strategy, a plan. And you are right, the Congress has the job of appropriating the money, and then the President has to sign the appropriations bills to see that the money is there.

The problem is that the process is stuck. We are not getting the recommendations on policy. We are just drifting along here.

Have you had to lay people off in NASA now?

Dr. FLETCHER. I will have to defer to Mr. Newman. There have been some layoffs, but we really have not made large cutbacks. That does not mean we will not have to.

Senator RIEGLE. Well, I would like the answer to both parts. I would like to know how many layoffs have occurred thus far and are immediately contemplated, and then I would like to know what the layoff impact would be if the funding that you get is at this lower level that you would call devastating.

I would like to have some sense as to what the fallout would be in terms of people having to be laid off.

Maybe Tommy—and I am sorry, I keep calling him Tommy. We have Tom on my one side and Tommy on the other side, so we have to distinguish Mr. Newman.

I might say that he might give us his best guess.

Mr. NEWMAN. Well, we have about 85 percent of the people that we employ, about 85 percent of our money, goes to contractors as opposed to civil servants. We have not conducted a reduction in force of the civil servants, although we have placed a hiring freeze at the time of the Gramm-Rudman-Hollings cutback for this past year.

In the contractors, we know of layoffs equal to about 3,000 people.

Senator RIEGLE. 3,000 layoffs in contractors at this point?

Mr. NEWMAN. Yes.

To the extent that we fall short of our budget, for every million dollars that we are short it is probably around 25 to 30 jobs that would be lost, primarily in the private sector because we are heavily contracted. If we were $100 million short, you would say maybe 250 jobs—I am sorry, 2500 jobs for each $100 million.

Senator RIEGLE. So in the magnitude of this shortfall we are talking about, what is the range of the potential additional layoffs that we might be having to expect here?

Dr. FLETCHER. If I might answer that question in this simple way, there is a $1 billion shortfall that we are facing, and that is not the exact number. What would be the number of jobs corresponding to that?

Mr. NEWMAN. It would be around 25,000.

Senator RIEGLE. Another 25,000 jobs that might disappear in the supplier sector?

Mr. NEWMAN. Yes, sir.

Senator RIEGLE. Now, if I might continue on this for just a brief moment, because I see that my time is up, if you were to have that kind of interruption, that kind of downsizing in the supplier effort, and the layoffs and so forth, in terms of the ongoing momentum of the contracting process, the things you have out there that are being done, everything from fixing the shuttle and the O-ring type work that is going on across to the other lead time items that people are working on, what would be the kinds of activities that would be cut into that would be represented by the shutting down of those contractor activities and those layoffs?

Dr. FLETCHER. Again, I will start out, but we really haven't examined in detail where we would make those cuts. As I say, it would be devastating, but without looking at the details we cannot say where the cuts would be made. The overall impact would be that we would lose enormous momentum in the space program, no matter how we cut, and it would take us years to recuperate from that kind of cut.

Senator RIEGLE. Tommy, did you want to add something?

Mr. NEWMAN. Yes, I would like to add a little to that. The reductions that we have been taking are in a sense the easier, the kind of reductions that involve the technicians and the support people, and we have attempted to preserve the core of capability, the engineering talent, and the people who have developed systems and know-how to get the system fixed. If the cuts got to be of the magnitude that you are talking about here that is being discussed, there is no way that that core capability could be retained in an effective fashion, so the impact would be more than simply reflected by the numbers. It would require rebuilding the capability as well as just a simple loss of the time of the people.

Senator RIEGLE. I would think if that happens, if we cut into that core capability, which is not easy to assemble, you are talking about people with extraordinary talents and engineering capability and so forth, that it takes a long time to assemble those teams. If those teams are broken up and people have to go out and find other work in other locations, I should think it would be very difficult even if the money were later forthcoming to put those teams back together on an orderly basis. Am I correct?

Dr. FLETCHER. That is absolutely correct, Senator Riegle. It could easily take ten years to replace if it were that size cut to replace the skills that will be lost in NASA because they would vanish to the four winds, and then we would have to build up that capability again. It takes a long time to build a capability such as we have at NASA.

Senator RIEGLE. I thank the Chairman.

Senator GORTON. Senator Gore.

Senator GORE. Thank you very much, Mr. Chairman. Just building on my colleague's last question, how much, Mr. Newman, would it require to keep the engineering teams in place if we later decided to go forward with a fourth orbiter?

Mr. NEWMAN. I believe that when I outlined the requirements that would come to $8.2 billion, including the supplemental amounts from last year, clearly, that level would enable us to be in a position for most of the coming year to proceed with a replacement orbiter.

Senator GORE. I am talking about the long lead items to maintain the engineering teams. We have a staff estimate of $50 million on that.

Mr. NEWMAN. I think that is a pretty good estimate of the amount that you would need to put into it some time in the next several months to maintain a good capability to proceed with the replacement.

Senator GORE. But that is not in this budget request?

Mr. NEWMAN. That is not in this budget request.

Senator GORE. So if we adopt the administration's request, we will in effect be making the decision on the fourth orbiter at least insofar as those engineering teams are concerned, because they will be disbanded, and if we later decide to go forward with a fourth orbiter, it will be very, very difficult, and much more difficult and much more expensive to do so. Is that a fair assumption?

Dr. FLETCHER. I think that is correct, Senator Gore. It would delay the starting of the replacement orbiter, and it would be more expensive. Both those statements are true.

Senator GORE. Now, another item that is not covered in the budget request concerns implementation of the Rogers Commission recommendations on vertical test stands, second sourcing, safety systems on the orbiter. Those items are not included either, are they?

Dr. FLETCHER. Well, Senator Gore, some of them are included.

Senator GORE. I do not think any of the ones that I mentioned there are included. You have included some $45 million—excuse me, $94 million in fiscal year 1987 funds and $106 million from the fiscal year 1986 supplemental for Rogers Commission recommendations, but when we look at the recommendations that are covered, we see that some of the Rogers Commission recommendations such as vertical test stands, second sourcing, and safety systems in the orbiter are not included. Is that correct, Mr. Newman?

Dr. FLETCHER. I think Mr. Moser could more properly answer this.

Senator GORE. Thank you. Whoever could more properly answer.

Mr. MOSER. We have not included the vertical testing. We are still studying that. It is probably going to be a matter of several weeks before we reach that conclusion.

Senator GORE. But the money is not going to be there, right?

Mr. MOSER. The money is not there for vertical testing. That is correct. Some of the orbital improvements, though, that you mentioned——

Senator GORE. Safety systems?

Mr. MOSER. Safety systems. Some of the safety systems have been incorporated. Crew escape has not been incorporated to the full extent to implement, but we do have funds planned for identifying the requirements and letting us make the decision.

Senator GORE. Now, the Rogers Commission recommended a crew escape system?

Dr. FLETCHER. No, they recommended that we consider crew escape, and we are seriously considering that, Senator Gore.

Mr. NEWMAN. Senator, I think we need to add that $200 million as an estimate of what we think the costs might be based on what we know now. There will obviously be adjustments and changes to the content of that figure as we better define the response to the Rogers Commission.

Senator GORE. All right. Now, implicit in the Rogers Commission recommendation to study a crew escape system is that you implement it after deciding upon study that it is needed. What you have eliminated or what has been eliminated not by you but by OMB and the White House, what has been eliminated is the money to implement a crew escape system if the study indicates that it is needed, correct?

Dr. FLETCHER. I think that is correct, Senator Gore.

Senator GORE. All right. Again, there is a long list. I see the yellow light going on, Mr. Chairman.

Senator GORTON. We will have more than one round.

Senator GORE. I appreciate that. Do you have money to reflect the shift of Galileo and Ulysses to ELVs? Yes or no?

Mr. NEWMAN. No, we do not have that in the budget.

Senator GORE. Do you have the money to reflect the NASA Centers' estimates of possible shuttle operation savings in fiscal year 1987? We have a $100 million estimate for that. Are you familiar with that item?

Mr. NEWMAN. I am familiar with that. We basically have been working on that a good deal since we developed—that was an estimate of the difference between what they had estimated and what we had estimated earlier. Those differences are being resolved.

Senator GORE. Let me come back to this in my second round, but let me ask you a question at this point, Dr. Fletcher. The President made a wonderful, moving speech after the *Challenger* tragedy, and part of the message of that speech was, we are not going to let this tragedy stop the space program. We are going to move forward, because a failure to do so would not honor the memories of the people who were lost.

Does the President personally know that he is requiring you to give us a proposal that in your words would devastate NASA in the wake of the Challenger tragedy?

Dr. FLETCHER. Well, the President supports that original speech. He personally wants to go ahead with the replacement orbiter. He wants to continue the program as I indicated, and there is the problem of where the money is going to come from. That is what has taken so long.

Senator GORE. Does he know that his proposal which he is foisting on you is going to devastate the agency?

Dr. FLETCHER. Of course he does not know about the proposed cuts that Senator Riegle and the rest of you mentioned.

Senator GORE. But they come from the executive office of the President, Dr. Fletcher, right?

Dr. FLETCHER. As I understand it, that is correct.

Senator GORE. Does he know that the proposals that he and his office are forcing upon you will devastate NASA?

Dr. FLETCHER. Well, so far he has not forced anything below the $7.7 billion budget request that we are submitting to date.

Senator GORE. Dr. Fletcher, you know that what we are talking about is $7.3 billion. Your budget officer has just testified that what NASA needs in order to continue moving is $8.2 billion. We know and you know that you went down there to OMB and to the White House and argued that if we are going to continue NASA's mission we have to adequately fund it and not pretend that nothing has happened. What I am asking is, have you personally talked to the President about this?

Dr. FLETCHER. Many times, Senator Gore.

Senator GORE. Does the President himself know what you are telling us? You just told us a few moments ago that this budget would devastate NASA.

Dr. FLETCHER. Senator Gore, the budget we have presented still is the $7.7 billion budget.

Senator GORE. Is that adequate for it to continue NASA's mission, Dr. Fletcher?

Dr. FLETCHER. It is approximately adequate if we get the money——

Senator GORE. Dr. Fletcher, we had an exchange back during your confirmation hearings about candor and about the quality of advice coming from NASA's leadership to the Congress, and I want to know from you whether it is your best judgment that the budget request you are submitting to us is adequate for NASA to continue moving forward in the wake of the Challenger tragedy.

Dr. FLETCHER. Assuming that we get the reimbursement from DOD, it is adequate, but just barely so to move ahead as I indicated with the space station with the replacement orbiter—not with the replacement orbiter on schedule, however.

Senator GORE. But it includes no money for keeping the teams in place for a fourth orbiter, correct?

Mr. NEWMAN. Senator Gore, may I elaborate a little?

Senator GORE. Well, my time has run out. I appreciate the indulgence of the Chairman, if he might continue.

Senator GORTON. Yes, continue.

Mr. NEWMAN. If we get the DOD reimbursements, then the $7.7 billion plus the $400 million available from the supplemental appropriation would put us at about $8.1 billion. At that level we would be $100 million more or less short of the $8.2 billion if we get all of the requests that is in the President's budget and we apply the supplemental and we get the DOD reimbursements, then we would be within about $100 million of the figure today cited earlier. If any of those conditions does not prevail, that is when Dr. Fletcher said that we would be in a potential disaster situation.

Senator GORE. I will pursue that later. Thank you, Mr. Chairman.

Senator GORTON. Senator Rockefeller.

Senator ROCKEFELLER. Mr. Chairman, I agree with the thrust of what Senator Gore is saying, and I understand the very difficult position that Dr. Fletcher must be in. We are under Gramm-Rudman-Hollings. There are limited funds. Your allegiance is to NASA. That is why you came back. You want to see it done right. You don't want to be critical, openly critical in quite so public a forum, I would suppose, of budget process. But on the other hand I get no sense from what I have read and some of the questions that Senator Gore brought up with respect to DOD reimbursements to NASA Center estimates of possible shuttle operation savings, the Rogers Commission, the Galileo, Ulysses, ELVs, and a variety of other things, much less the fourth orbiter. I get no coherent sense that we are about to thrust at you a budget with which you really can live in a sense of comfort.

I expressed concern, frankly, on our approach. It is not my impression that the final budget appropriations comes from this committee. We are the authorizers. We are the people, as I said in my opening statement, who ought to be saying what should be done, and we should exercise leadership in your behalf and in NASA's behalf together with you for what needs to be done. In fact, there is some potential indication that Senator Garn in the appropriate Subcommittee on Appropriations may want to do more than the $7.3 billion, or may very well want to do more than the $7.8 billion. I don't know why we are constraining ourselves here to figures which I don't believe you feel really reflect what you want to do.

I mean, I hear your struggle. I hear you are being torn, but you came back to do a job. As I expressed my feelings about you during confirmation hearings, I think you are exactly the fellow to do it. You didn't want to come back at all, but you did come back, and I think the nation is better off for it, but I think this is the chance to fight for budget. I see this as the year, if we go $7.3 billion, Gramm-Rudman-Hollings to the contrary—you know, there are a lot of things that could be done around here if we had more revenue, and there is a bipartisan coalition in the Congress for more revenue for a variety of efforts.

Where there is not agreement on that is at the other end of this avenue, and hence we are stymied, but that should not stymy us in terms of an authorization process. We are an authorizing committee. We are meant to chart the future of NASA. We have not done that adequately in the past. We have not done oversight adequately in the past. I mean, NASA gets the blame. And others, private contractors, get the blame, but I don't think we have done what we should have.

Now, here we have a chance in the authorizing committee to talk about money that we need, that you need, that the country needs, and NASA strikes me as the kind of committee, the kind of operation that if it gets something like 80 percent funding it is like cutting it in half. I mean, you do not do to NASA what you do to the Export-Import Bank or something of that sort. There is a critical level beneath which you cannot go without fundamentally compromising the momentum and the morale of your agency.

I would hope that frankly, and this is more of a statement than a question, that you would join with us on helping us search out a proper budget process and then if because of Gramm-Rudman-Hollings or any other process we cannot come by that, then we will have failed, but this budget session is not over. Gramm-Rudman-Hollings is not concluded yet. There are still chances for revenue increases. A bipartisan coalition of Senators has thrown the gauntlet down to the White House to join us in raising more money for a variety of purposes, including defense, and including, among other things, NASA.

I agree with Senator Gore. Neither the President nor we can go through what we did on a national basis, this orgy of self-flagellation and noble pity and noble purpose after the *Challenger*, and then come in the relative quiet of the budget process and slaughter the lamb and call it NASA. It does not work like that. It cannot work like that. We have not even discussed the fourth orbiter. I have no idea what that would cost these days. It was $2.3 billion when I last heard. Now I assume it is probably going to be around $3 billion, but we are not even discussing that this morning. It was my impression that you felt we ought to have a fourth orbiter. I think most of the scientific community feels there ought to be a fourth orbiter.

Now, we are constrained from getting into that because of our sort of being held to $7.3 billion or $7.7 billion. I think you are really talking about $8.2 billion at a minimum, and probably more. If you would care to comment on that, fine. I apologize for not asking you a question, but I feel very strongly that we are at the point of simply abrogating our responsibilities in this authorizing committee on a year that is so crucial to NASA.

Dr. FLETCHER. Senator Rockefeller, I would like to respond simply to clarify the record. There are a lot of numbers floating around, and I would like to go through them carefully. We have asked for $7.7 billion in fiscal year 1987. We have a $.4 billion carryover from fiscal year 1986 which was part of the urgent supplemental passed by you all. That comes to $8.1 billion, or $8.2 billion, actually. That is what we are submitting. We are not talking about $7.3 billion or anything else. We are also assuming that we will get $500 million and something, $530 million, is it, from DOD as reimbursement.

Senator ROCKEFELLER. But you are not sure you are going to get that.

Dr. FLETCHER. We are not sure. Let me finish the statement. Even if we get that money, the $531 million, from the DOD, it does not include money for a replacement orbiter. It does not include any money for expendable launch vehicles for taking care of, say, the Galileo mission and things of that sort. But we are going to be short even if all the money comes down the pike that we expect. So in summary, yes, if DOD does not come up with or give us back the money they owe us, so to speak, and if you decide to cut us more, then we cannot function. It will be devastating.

However, with what we have submitted, we will provide most of what NASA needs if all of those things come to pass, and I agree with you, it is not at all sure at the moment. I want to reemphasize again that it does not include any money for a replacement orbiter. It does not include any money for ELVs, and of course it does not accommodate any of those proposed cuts that we keep hearing about.

Senator GORTON. Dr. Fletcher, I would like to get from general subjects to a specific one which has been somewhat in the news lately. I gather that you made some tentative management decisions based on the Rogers Commission report about the centralization of the space station project. I gather that that decision, if it were implemented, would have an impact which Houston does not like very well, and that you have been beseiged by a large number of the members of the Texas delegation.

Would you tell me whether or not my assumptions are correct as to the driving force behind that decision and where you intend to go from this point forward?

Dr. FLETCHER. Well, Mr. Chairman, as you know, the Rogers Commission suggested that we tighten up our control of programs at headquarters. The first move of General Phillips' committee, the first suggestion that came from him is that we move the management and the systems engineering function of the space station to headquarters. At the same time he suggested a realignment of the work packages as they were proposed to go to the various centers. Apparently the Texas delegation wasn't happy about the proposed realignment, so we simply decided to take the stand down for 90 days and take a hard look not at just that but at a lot of other things involving the space station, and we plan to do so.

Senator GORTON. You are sort of like the Department of Defense with respect to closing bases, I take it, in the abstract if members here wanted to do things in the most efficient and possible fashion as long as it does not affect what takes place in their state or their districts.

Dr. FLETCHER. That is not a bad description, Mr. Chairman.

Senator GORTON. Would you describe NASA's analysis of what kind of options it has to replace the shuttle Centaur program and what implications there are with respect to the budget?

Dr. FLETCHER. On the second part of your question, implications on the budget, I would defer to Mr. Newman, but in essence there are three what we call outer planetary missions, the largest being the Galileo mission to Jupiter, but another one being the Magellan mission, and the last being the Ulysses mission. The Ulysses mission is a solar polar orbiter, as we call it. These require very large payloads. We have a choice of going to a new expendable launch vehicle which the Air Force has been proposing and is planning to build which is called the CELV, the complementary expendable launch vehicle, lately renamed TITAN IV. We could go on each of those, with the expendable, the Defense Department expendable, or we could launch probably, and we have not really made the final decision on this, at least the Ulysses and the Magellan on the space shuttle using the inertial upper stage which has been designed as an upper stage for the shuttle. We could in principle, in fact, even launch the Galileo, which is the heaviest of these payloads, on the shuttle, but it would have to be done in two pieces. It would take too long just to do that, and whether we can fit that into the manifest or not is something that is being deliberated, but if we could, it would be less costly, and hopefully it could be done within some of the out year budgets, but we are not really ready to say we can do it that way, but those are the options for those outer planet missions.

Now, there are many other science missions that would be impacted, but most of those can be handled with the shuttle alone or with the shuttle plus an initial upper stage. Mr. Moser, if I have said something wrong, please correct me.

Mr. MOSER. No, you said it exactly correctly. We are looking basically at upper stages in the orbiter as the means of delivering the planetary missions and in parallel looking at the expendable launch vehicles as a method, and we expect to have those studies complete around the October time frame.

Senator GORTON. And what kind of budgetary implications, top and bottom, would there be with respect to them?

Mr. NEWMAN. With respect to fiscal year 1987, if you compare the requirement to go to the interim upper stage as opposed to what we had planned for the Centaur, there is a net increase of about $26 million. We save money by cancelling the Centaur, but we have to devote about $85 million to beginning procurement of those stages. If we went to the expendable launch vehicles, there would be on top of that another $70 million or so requirement in fiscal year 1987.

In the long term, the science projects would be affected, but basically they would be the estimates we have provided to the staff with the effects of departing from the Centaur and going to the alternate route.

Senator GORTON. Senator Reigle?

Senator RIEGLE. Dr. Fletcher, the Department of Defense has just announced plans to buy ten extra ELVs, as you know. These are not cheap. The cost of that is about $2.5 billion more for the Air Force. I am just wondering, is it feasible in your mind to think that DOD can go out and buy those and still pay you the money that they are obligated to pay you even though they say they want to pay it? Are we not finding ourselves splitting off in different directions here that make this impossible?

Dr. FLETCHER. My judgment is that indeed the Department of Defense can afford that by taking it out of some other part of the Department of Defense, but they have their internal difficulties as well. All I care about, and Senator Riegle, I am sure that the Defense Department cares the same, is that they pay us the money they owe us.

Senator RIEGLE. Well, that does not seem to be forthcoming at the moment, though, does it?

Dr. FLETCHER. It depends to some extent, Senator Riegle, on what you and your colleagues in the Senate decide and what the House decides. That is still open for debate.

Senator RIEGLE. What is the President's view on that?

Dr. FLETCHER. The President's view I do not know, but I discussed this with OMB, and they are very upset that the Armed Services Committee denied us that money.

Senator RIEGLE. Now, you indicated earlier that you have talked to the President a number of times. I would think that the next time you talk with him, that ought to be an item to raise because his opinion does matter if he has an opinion on that issue, but you have not done so as yet?

Dr. FLETCHER. Not on that particular issue, Senator Riegle, no.

Senator RIEGLE. How do you feel about the announcement the other day from the SIG group that NASA is going to move out of the commercial launch business?

Dr. FLETCHER. Well, I think if it does so in an orderly fashion, I would not object very loudly, but the proposal that was made I did not like one bit because it was suggested that we simply contract, I mean, that we cancel all of our contracts that we had made with foreign governments and commercial satellite producers. I think that would be a wrong thing to do.

Senator RIEGLE. Assuming we did it on an orderly basis and we fufilled the contract obligations, which I also feel we should do, I think we are bound to do that. You then would be willing to accept the notion that NASA gets out of the commercial flight business?

Dr. FLETCHER. Well, if it is the will of Congress, and if it is the will of the President, I would go along with it.

Senator RIEGLE. Well, I guess I am asking you a different question, though. We are going to get to that, but I am asking now for your judgment as the head of NASA. Is that a sound policy approach, do you think, for the future? I know that when we have talked in the past you seem to be more of a mind to have a balanced program. We had NASA involved in scientific activities and research activities as well as Department of Defense activities, as well as commercial activity, and you seem to favor that. Have you changed your thinking on that?

Dr. FLETCHER. No, Senator Riegle. I think you have analyzed my own interests and beliefs quite accurately. I believe there should be a mixed fleet. We should have expendables, and we should have the main transportation system be the space shuttle. However, we are down for a period of time, like another year and a half, and we may be without a replacement orbiter for a period longer than that. During that down period we have to increase the number of expendable launch vehicles somehow. If I had my druthers, I would rather do it between the Defense Department and ourselves. We ought to be able to handle our customers that way.

Unfortunately, a policy laid down by the Congress and supported by the President in 1984 indicated the Department of Transportation should have that responsibility, and that is still on the books, and we have to deal with it.

Senator RIEGLE. Well, I will try to come back to that in the next round. You now say that it looks like we will be flying a year and a half from now. Is that now the latest estimate, that it will be 18 months from today roughly?

Dr. FLETCHER. Well, the first quarter of 1988 is what we have said. We have not pinned it down any more accurately than that. We hope that we will be able to in the next several weeks.

Senator RIEGLE. But no earlier than that as things look now?

Dr. FLETCHER. As things look now, Senator Riegle, it is awfully hard to move the schedule up.

Senator RIEGLE. I am not trying to push you any faster. I just want to get an accurate assessment.

Dr. FLETCHER. That is a correct statement, yes.

Senator RIEGLE. Now, if we do not get the replacement orbiter, when would you see us being able to complete the space station? Does that push that further out in time?

Dr. FLETCHER. At this point, Senator Riegle, I will have to retract statements I may have made publicly but not before this committee. I am not sure we can actually build a space station with only three orbiters. There is some disagreement within NASA on that subject. Originally I had thought we might be able to build the space station by simply stretching it out with three orbiters, but that depends on a lot of things.

It depends on no failures. I do not mean a catastrophic failure. I mean no difficulties during that process. It also does not allow for preventive maintenance, as we call it. And so whether it can be actually built in an extended period of time or not is still under debate within NASA.

Senator RIEGLE. Well, that is probably, I think, the most significant thing that has been said today. I am troubled to hear that, but I appreciate your honesty and your directness. If I understood what you said correctly, you are saying now that it is your own professional view that if we have to go with a three orbiter fleet, that there is now serious question as to whether it is feasible to go ahead and do the space station?

Dr. FLETCHER. Well, I would rather say it a different way. We might have to come up with a different space station that we can build with the three orbiters. That would be the way that I would prefer to say it.

Senator RIEGLE. Well, then, that also means that the space station we have been designing and planning to build we would not be able to build with a three orbiter fleet.

Dr. FLETCHER. That is quite possible, Senator Riegle. I do not want to say for sure, because we have, as I indicated, some disagreement within NASA on that subject.

Senator RIEGLE. But with respect to your view on this?

Dr. FLETCHER. That is my view.

Senator RIEGLE. That is your view. Now, if I may, I think this is important enough to continue, at least just for the moment. We are tied into a number of international agreements with respect to the space station, and I think properly so. We are trying to undertake this on a cooperative basis. If we had to scrap our current plan for the space station and scale it down to something different over a different time frame, would that not create enormous difficulties?

Dr. FLETCHER. Senator Riegle, you are right, but I do not want to be as pessimistic as this body seems to be. I am very optimistic that we will have a replacement orbiter, and I think an announcement to that effect will be soon. I think the only question is, when we start going, start to build that fourth orbiter replacement orbiter. I am optimistic that that will be forthcoming.

Senator RIEGLE. Well, I will just finish by saying that I hope I can share your optimism, because I also think we need a fourth orbiter, but I think just as importantly it seems to me what you have said is that if you do not get it, if you do not get it and you have to operate with three, that that now changes in a very material way our ability to stay with our original space station concept and plan.

Dr. FLETCHER. I think that may very well be the case. It is my opinion, but remember, I have only been there three months, but I have listened to all the troops, it is my opinion that would be required. Yes, sir.

Senator RIEGLE. I will come back to that in the next round. Thank you.

Senator GORTON. Senator Gore.

Senator GORE. Just briefly, am I correct in assuming that the White House is paralyzed on the subject of a fourth orbiter?

Dr. FLETCHER. I would not describe the White House as being paralyzed. There are differences of opinion as to whether the fourth orbiter should go ahead. That debate is still going on, but as I indicated just a moment ago to Senator Riegle, I expect a decision will be forthcoming very shortly on that fourth orbiter.

Senator GORE. Well, we have expected that a decision would be forthcoming very shortly for a period of several months now, and it never seems to come. If we started construction in fiscal year 1987, that would be an additional budget requirement of $250 million, correct?

Dr. FLETCHER. The exact amount, of course, we have asked for $800 million, Senator Gore, for fiscal year 1986 and 1987. That is what it would take to build a replacement orbiter on schedule, in other words, in a timely fashion. We would, of course—you are talking about the replacement orbiter now, right?

Senator GORE. Right.

Dr. FLETCHER. Of course, we would accept any amount of money that we could get, but of course less than the $800 million would require a delay in the provision of the replacement orbiter.

Senator GORE. What is your assumed delivery date in that $800 million?

Dr. FLETCHER. In the $800 million I think we thought we could have a delivery date early 1990 with—I think you said $250 million, that would put it in late 1991.

Senator GORE. All right. And that conforms to the Vandenberg decision, correct, the delay to late 1991?

Dr. FLETCHER. It conforms to the Vandenberg decision, but of course that is not in our purview.

Senator GORE. I understand, but we are working with the estimate of $250 million if we started construction of the fourth orbiter in 1987. Now, do you include money in your budget request for hiring or rehiring quality control and safety inspectors?

Dr. FLETCHER. To a first approximation, Senator Gore, we have—the problem there, Senator Gore, is not quantities of people, not large quantities of people, but very capable people.

Senator GORE. Well, the Rogers Commission disagrees with that, Dr. Fletcher. They talked about the number of quality control and safety inspectors that had left NASA and have been let go from NASA. They say that the numbers of people are also a problem. Do you disagree with the Rogers Commission on that?

Dr. FLETCHER. I do not remember the exact statement.

Senator GORE. Well, I cited the exact quotation to you the last time you were at the witness table. You did not recall it on that occasion either, but I read you the exact quotation. Do you still disagree with them?

Dr. FLETCHER. No, I do not disagree with the Rogers Commission at all. If additional people are required, we will provide those additional people.

Senator GORE. Are they reflected in this budget request?

Dr. FLETCHER. If they are required, we can accommodate them in this budget request. Yes, sir.

Senator GORE. How many?

Dr. FLETCHER. Well, I have not looked at numbers.

Senator GORE. Where will you take the money from?

Mr. NEWMAN. The $200 million that we mentioned would be—a response to the Rogers request did include in our mind increased inspection activities both on the orbiter and on the solid rocket booster.

Senator GORE. An increased number of quality control and safety inspectors?

Mr. NEWMAN. The inspection would involve an increased number.

Senator GORE. How many?

Mr. NEWMAN. I cannot give you that number right now, but we can provide that.

Senator GORE. Any new people?

Dr. FLETCHER. Of course there will be new people.

Senator GORE. Any additional members of quality control and safety inspectors, Mr. Newman? Are you sure about that?

Mr. NEWMAN. In the inspection activities there would be additional people.

Senator GORE. All right, fine. Supply that for the record.

[The following information was subsequently received for the record:]

It is difficult to estimate the increase in safety, reliability and quality assurance people at this time, because a number of hardware changes and related activities are under definition. The people involved fall into several categories. A survey of the expected increases at the three NASA centers primarily involved indicates an increase of about 200 civil service people, primarily in engineering functions of safety, reliability and quality assurance, and in inspection functions.

The $200 million identified for compliance with the Roger's Commission recommendations together with the funding identified for anomaly resolution will involve a considerable, although not yet quantified, increase anticipated in contractor personnel in SR&QA and related functions associated with the major design reviews and hardware recertifications that have been initiated following the Challenger accident. This process has been initiated to insure that the flight hardware, software and processes are safe and reliable. As operations resume, there will be an increased level of inspection and quality personnel to insure that the shuttle safety and reliability requirements are satisfied.

Senator GORE. Would you agree that it would be a good idea from here on out to have a separate line item on quality control and safety so that we could look and see what is happening there?

Dr. FLETCHER. Senator Gore, I would not object to such a statement because we plan to implement pretty much the Rogers Commission recommendations.

Senator GORE. Fine. Now, let me try to pin down these numbers a little bit. You have said that what you need is $8.2 billion, $8.214 billion, to be exact. Now, you are assuming in that $.426 left over from last year's supplemental. Now, that leaves you $100 million short of what you say you need. It also assumes that you will get $531 million from the Defense Department, although no one expects you to get the $531 million from the Defense Department, including you.

So, the way I look at it, you are $631 million short of what you need, and if you include the requirement for constructing, beginning construction of a fourth orbiter, then you would be $881 million short of what you need, and if you assumed that some of these other issues which I raised earlier like the escape system for the orbiter or second sourcing for the SRB, if you assume that those items are also going to have to be paid for, then you are approximately $1 billion short of what you need.

Now, let me focus, if I may, on the $531 million from the Department of Defense. That is the biggest single item here. They pay in advance for services expected to be rendered, correct?

Dr. FLETCHER. That is the normal procedure. Yes, Senator.

Senator GORE. All right. Now, if they pay in this year's budget, which they won't, but if they did, then you would have to give them a credit for that amount in next year's budget, correct?

Mr. NEWMAN. Yes, sir. The agreement that we made with DOD some time ago to get some stability into the budget was that we would determine at the time the budget was developed the amount of reimbursement they would make to us. They would adhere to that amount in the budget year, and we would make an adjustment in the subsequent year. The terms of the agreement are that they pay in fiscal year 1987 for launches in fiscal year 1988, and so forth.

Senator GORE. Right.

Mr. NEWMAN. The reason for that is that the costs are incurred to build the hardware and have it at launch time.

Senator GORE. Do you expect those launches to occur in fiscal year 1988?

Mr. NEWMAN. We will be launching for them in fiscal year 1988, but we will owe them a credit.

Senator GORE. You will owe them a credit. Now, Mr. Chairman, I would like to get your attention and the ranking minority member's attention on this point, because I think it is critical in understanding the way NASA's budget is constructed here. They are saying it is a good thing for the Department of Defense to pay them the $531 million this year. It is not going to happen, but they think it would be a good thing. However, because of the launch delays, because of the way the budget is structured, that means that they would owe the Department of Defense a credit of $531 million in next year's budget, in the fiscal year 1988 budget.

Now, if you assume from our standpoint that the budget pressures are going to be even worse because of Gramm Rudman and because of a variety of other factors, if you assume they are going to be even worse next year than this year, then it may be a good thing from NASA's standpoint to not have that credit appear in next year's budget, and instead make the straightforward case recognizing what is happening with the pressure on DOD's budget and say, look, we need an extra $531 million to make up this loss in this year's budget. In addition, we need an extra $100 million to make up the shortfall for our minimum needs, and we need some contingency funds, and you ought to come and say, although I know it is tough, you ought to come and say, look, the White House and the Office of Management and Budget are not giving us what we think is the minimum requirement for moving NASA forward and not letting this tragedy destroy the agency.

Now, you all are unwilling to do that. And I think I understand the reasons why, but the times are so extraordinary that I think that the country would be well served, quite frankly, if you would be candid and tell us that.

Dr. FLETCHER. Senator Gore, as you know, I represent the President at these hearings and I represent the President's budget. What you say, though, is absolutely true. If it is clear that we are not going to be reimbursed by the Defense Department, and if it is clear that we have to go ahead with the escape system and the second source SRB, we would have to then request additional funds.

Senator GORE. I do not know what our situation is here. Can I ask another question?

Senator RIEGLE. Please do.

Senator GORE. All right. On the second source, how much would you estimate it would take to implement the recommendation of the Rogers Commission for second sourcing on the SRB?

Dr. FLETCHER. Well, we have an estimate for fiscal year 1987. Tom, do you have that number?

Mr. NEWMAN. Our estimate, if we went fully into implementation, it would be on the order of $50 million in fiscal year 1987, and perhaps $150 to $200 million in total.

Senator GORE. Okay, that is not an item that was cut out by OMB. That is something you did not recommend, correct?

Dr. FLETCHER. That is because a decision has not been made. We expect to make that decision at the end of this calendar year, as Mr. Mosher has indicated, depending on a number of studies that are going on at the present time.

Senator GORE. The Rogers Commission recommended it, did it not?

Mr. MOSER. They did not to my knowledge address a second source.

Senator GORE. All right. We are going to try to get the exact language. It is my understanding that they strongly endorsed it. There may be a difference here.

Dr. FLETCHER. Senator Gore, some of the things in the Commission's report appeared in the narrative, and some of them are in the nine recommendations. It is my recollection that it did not appear in the nine recommendations.

Senator GORE. When do you expect a decision on a second source?

Dr. FLETCHER. At the end of this calendar year, Senator Gore.

Senator GORE. All right. The language there of the Rogers Commission is not a flat recommendation on that. It says that the faulty solid rocket motor joint seal must be changed. This could be a new design eliminating the joint or redesign of the current joint seal. No design option should be prematurely precluded because of scheduled costs or reliance on existing hardware. That seems to strongly imply looking for another possible source.

Dr. FLETCHER. And we are doing that, Senator Gore. That is the purpose of the study that is now ongoing.

Senator GORE. But there is no money to implement it if it turns out that a second source is advisable?

Dr. FLETCHER. That is correct, Senator Gore.

Senator GORE. Okay. My time is up, and if we have another round I will come back. Thank you.

Senator RIEGLE. Dr. Fletcher, Senator Gorton had to go to the floor to attend to a matter that required him to leave at this time, so he will not return. He does have some additional written questions that he has asked that you respond to for the record, and those will be given to you at the end of the hearing.

Now, you have under way presently a National Space Transportation Study with NASA and the Department of Defense together to try to map out what the future is going to be in terms of U.S. space effort. Where does that stand at the moment and when will we be getting that report?

Dr. FLETCHER. Well, Senator Riegle, that is a long-term study, and I do not remember whether there is a termination date on it, but there is a joint study with the Defense Department looking at the next phase of space transportation, and it consists of two parts. One is a heavy lift launch vehicle, and the other one is a different way to get people back and forth to space. We are focusing primarily on the second of those two options. That, of course, was started long before the accident, but it is still going on. I do not believe there is a termination date. That study is being done primarily by our own in-house people at the Aeronautics Centers by and large, but to some extent at the Johnson Space Center.

We do not anticipate any recommendations out of that study for several years. Maybe Mr. Moser has a better estimate. But as far as I know, we have no termination date on that study.

Senator RIEGLE. My understanding was, we were supposed to have it in May of this year. Is that incorrect?

Mr. MOSER. That report has been prepared. It is in coordination at this time, and it is focusing primarily on the technology which must be addressed to complement the architectural studies which are ongoing.

Senator RIEGLE. When are we likely to get it?

Mr. MOSER. I think it is almost imminent. We have a little bit of difference. There are some minor details between ourselves and DOD in the way to summarize the report, but the content is there and it is imminent.

Senator RIEGLE. End of the year, do you think?

Mr. MOSER. Oh, before then, sir.

Dr. FLETCHER. Senator Riegle, it is only on the technology studies, not on the configuration studies.

Senator RIEGLE. Let me tell you why I asked that question, and I really want to invite the attention of everybody in the room to this. I think what is happening here is, there is something going on that has not been articulated yet or really brought into focus, and that is that I think what is happening here is that the NASA Space Agency is in very serious difficulty for a lot of obvious reasons. You are nodding in the affirmative, Dr. Fletcher. I would just note that. There are a lot of tough problems there to deal with, and yet at the same time over the last few years the Defense Department has gotten into the space program business in a major way. Their budget this year is $15.2 billion. It is more than twice what you are in here seeking now with respect to what you have said to us bluntly is really too little, and that is a hopeful budget in the sense that certain things have to happen, and if those fall out, then you are in deep trouble to the point where you would describe the effects on NASA as being devastating.

At the same time that the Air Force and the Defense Department has a space program that is now twice as big, they have just made this commitment for these additional ten ELVs, and that is another $2.5 billion, and as I understand that, that is going to be an add-on, so that would be in addition to their basic budget, so they are apparently finding it easy to go into the policy meetings or to go wherever the approvals have to be gotten to get large chunks of money, big money, and you are finding that you are getting stonewalled even on very minor amounts of money, notwithstanding all the other statements that have been made, all of the expressions of the President and others about the sadness of the accident, and so forth, and getting NASA back on track.

When we get right down to the bottom line, in terms of the policy decisions, we see one space agency robustly funded, moving ahead, showing lots of strength, lots of support on the inside. We see the other space agency, NASA, the traditional civilian space agency, being squeezed and cramped and in real difficulty and desperately needing help, if you will, from a morale point of view and a restructuring point of view and a financial support point of view.

It seems to me as if you are getting blocked at every turn. You are finding it very, very difficult to get the things done that at a minimum you feel need to be done. Is that a fair characterization?

Dr. FLETCHER. Senator Riegle, it is a pretty good characterization of where we stand on funding. It impacts the whole agency, as you properly indicated, and in the long range it will impact on the space program's future.

Senator RIEGLE. This brings me to the look ahead that I want to try to articulate here. It is always hard to look into the future, and that is one of the big failures, I think, in the Congress, that we tend not to try to look ahead far enough, but as I extend these trend lines, the growth in the defense space program, in a sense the shrinkage in the NASA space program, the fact now that there is a policy recommendation that NASA be squeezed out of the commercial launch business, that the big push on ELVs is now going to be apparently over in the defense space program, I think one of the things that is going on here is, you have to fight for survival in terms of who is going to run the U.S. space program and what its character is going to be, and the Defense Department is winning, and NASA is losing.

Now, that is the way it looks to me, and if these trend lines continue, if we continue to see this kind of differentiation in response where DOD's space efforts continue to get supported and lavishly funded, and the energy and all the big push is there, and over on the NASA side we find ourselves cramped and in a very difficult position with the mission shrinking, with the ambiguity about the replacement orbiter and so forth, it seems to me that we could run into a situation where you get NASA caught in a downward spiral. Whether that is anybody's intent or not, it could just start to happen, and you would have a harder time holding onto your good people, and the big effort would be over on the defense side, so there would be a movement not just of resources, but of attention and personnel over in that direction.

We could then find that NASA would continue to basically downsize and shrink in importance and mission and so forth, and at some point conceivably at some future date it could even disappear. Now, I raise that in relationship to this report, because it seems to me that the space station, if you will, if we are going to stay on track with that, and I think we should, I think there are important national security reasons to do that, we have to be thinking not only about NASA's role in that assignment, but what follows that.

In other words, you know, this requires long-range planning and long-range mission definition and so forth. I am now getting the sense, what I see and what I sense tells me that there has been a change in policy thinking within this administration, and there is a tilt now toward the defense space program and against NASA. I am only citing my own view, and I have touched on a number of the things today that are the objective facts that I think support that kind of judgment, but I think those are the trend lines that we are seeing, and I must say I am very disturbed about it, because you have NASA today in a very vulnerable position. You are vulnerable by virtue of the magnitude of the accident, by virtue of the fact that you are probably not going to be able to fly again for a year and a half, for the fact that you have a lot of expensive changes and corrections to have to make as mandated by the Rogers Commission, and yet you are not getting the financial support, the policy support, the decision support out of the administration that you need to be getting. You did not get it three months ago when it would have been more appropriate to get it, and you are not even getting it today, and it is not clear that you are going to get it in the future.

Now, I do not know where the President is in this project. I gather he may be somewhat disconnected from the intricacies of these decisions. It is a very complex matter and there is a lot of bureaucratic struggle that goes back and forth on these kinds of things, and I suspect he has a lot of other things to think about in his discussions with Gorbachev and what have you.

It may well be that down at the lower ranks beneath the President, whether it is at the level of Don Regan or with the people who are really the key players in the SIG group, this policy debate is being waged and the struggle is going on.

But it looks to me as if the military space program is winning and NASA is losing, and NASA is losing at a time when it is in trouble anyway. If that is the case, I think it is a very sad, sad commentary on where we find ourselves.

I think NASA has been an agency over the years that has performed remarkably well, not perfectly. There have been mistakes, not just the accident here and so forth. But I think when you compare the record of NASA over its long history with the record of other Federal agencies, whether it be the Defense Department or the human service agencies of government, I think NASA has performed to an extraordinary degree, and I think in a matter of great pride to the country.

But I think right now NASA is in a very vulnerable position, and it looks to me as if other parties who have their own interests are coming in and in a sense taking advantage of NASA's weakened condition to really grind you down.

I would hope that if that is the case or if those trend lines continue, that at some point, as a senior man as you are who has been through this and has seen a lot, if it looks as if this is the kind of track we are on and we are fighting a rear guard action for an agency that is not going to get the support it needs to really do its job, I would hope at some point you would not only say so clearly, because you know how to speak out forcefully and with a clear voice, but if it ever becomes obvious to you that that is the kind of dynamic we are caught in here I would expect you to be the guy to say so.

That would not be a walkout on NASA. But I think somebody has to stand up for NASA at some point, and you are it because you are the guy who is in the strongest position to look at this over a long period of time.

I do not want to see NASA bleed to death by a sort of thousand nicks in this bureaucratic infighting because somebody else has a different agenda that is more popular at the moment, which is what it appears to me may be going on here.

Dr. FLETCHER. Senator Riegle, if you do not mind I would like to respond to that.

Senator RIEGLE. Please.

Dr. FLETCHER. When you say NASA is losing, I want to be sure you understand that I, Jim Fletcher, have not given up, and we are still fighting the battle. We have not lost yet. We are still hoping that the Senate will restore that $531 million that the Defense Department owes us.

Whether that happens or not, I cannot predict. You are in a better position to predict that than I am. We do appreciate the 500——

Senator RIEGLE. Let me just say on that one point, because it is a key point, that we are not going to get that done if the President does not ask for it, and I mean clearly and strongly.

If it is not something that he wants or feels strongly about, you know, his party runs the Senate. You are not going to get a decision out of here that is contrary to his wish. And if he is silent, then I think the chances of getting it are very low.

Dr. FLETCHER. I understand.

The other point, though, that I think is important is that, even though the urgent supplemental started in the Senate, he did sign the bill that gave us at least a start on fixing the orbiter.

I can assure you, Senator Riegle, that the President is solidly behind a strong space program. But as you properly point out, he has a lot of other problems that he has to deal with.

I again want to emphasize that in my opinion a decision on things like the fourth orbiter will be forthcoming in the very near future. I may have said that before, but I believe it at this point.

I do not think he has been approached on the Defense Department reneging on the $531 million. But if in fact that happens, we will have to deal with it at the time. But right now we are hoping that the Senate and the House will restore that money.

Senator RIEGLE. I would just conclude before yielding to Senator Gore by saying that I think we stand at a point here where NASA is in jeopardy of beginning an irreversible decline. I think that has to be prevented. I think that it would be profoundly adverse to our national interest.

I think it would be a mistake, however you want to measure it, to take something as important as this, with the history that it has and the importance for the future, and allow it to begin to wither, even if part of those functions are being moved over into the defense area and given high priority.

I want to just state today that I think we are at the point of danger and jeopardy, that we could be beginning a period of irreversible decline. And I think unless we see that danger for what it is and act affirmatively to prevent it—and that means to do the things that we need to do—that we could well in the future look back and say: Well, this was the time that the direction changed, and that is the way it was.

I do not think it should be that way. I think we are going to have to fight very hard to prevent it, because it looks to me as if the trend lines right now are very ominous in that respect.

Dr. FLETCHER. I completely agree, Senator Riegle.

Senator RIEGLE. Senator Gore.

Senator GORE. Dr. Fletcher, a brief question on legislation that I have introduced with respect to whistle blowers working for Federal contractors. Given the outrageous treatment given to Alan MacDonald and Roger Boisjoly, would you agree that it is a good idea to give Federal contractor whistleblowers the right to sue and protect themselves?

Fifteen states currently have such statutes on the books. The Federal Government does not. I would like to include a provision of that kind in this year's bill.

Dr. FLETCHER. A, I have not studied the proposal in detail, but it sounds like it is on the right track, Senator Gore.

Senator GORE. All right. Thank you.

Now, let me go back to the budget for a minute. Before the *Challenger* tragedy, the Administration prepared a budget for NASA. It was submitted to the Congress a week after the *Challenger* tragedy.

Do you know what that number was, Mr. Newman?

Mr. NEWMAN. Yes. It was $7,694 billion.

Senator GORE. $7.69 billion?

Mr. NEWMAN. Yes.

Senator GORE. Now, in March NASA testified that there would be a 12 month delay before the shuttle could launch again, and the budget request at that time was $7.69 billion, is that correct?

Mr. NEWMAN. The budget was not officially modified. At that time we said that we were able to identify about $500 million of reductions associated with the delay. We had identified about $460 million of increases associated with the delay, and that left us with a fairly small amount of additional money to apply to the anomaly resolution.

Senator GORE. Then the following month, in April, the estimate of delay had increased to 18 months and the budget number stayed the same, $7.69 billion, is that correct?

Mr. NEWMAN. We never got or officially requested a change in the budget number. At that time we did identify additional savings and additional increases.

Senator GORE. Well, I have the budget document with all of your adjustments dated March 10, 1986, and the number is $7.694 billion, coincidentally the exact same number from——

Mr. NEWMAN. The reason for that is each time we could identify more savings we applied that to do as much as we could to resolve the problem.

Senator GORE. All right. Now, here it is August and the estimate for the delay has gone to 24 months, and again your budget figure is coincidentally $7.694 billion. Again, I think it is obvious what is going on, but it is not right.

I think I understand the fix that you all are in, and we have covered the ground pretty thoroughly. But I would like to conclude with just a brief statement, because I think that what we have here in essence is a government quality control problem.

We have the NASA officials warned the night before the launch in January, and for months and months prior to the launch, that the system was in a condition that made a launch unsafe and it should not go forward.

We now have the White House advised before the budget is submitted, for months and months before the committees of Congress act on the budget, that the budget is in a condition that makes it hazardous to the future of NASA. But the President apparently does not care.

either that or he has difficulty thinking about too many things at the same time, which would be understandable if he did not have such a large staff to help him keep up with these matters.

You, Dr. Fletcher, have testified this morning that you have spoken to him personally on several occasions about this budget problem, and you have said that you are sure he has a strong personal commitment to keeping NASA strong. Why does not that commitment get manifested in a request to the Congress?

That is the question I want to ask.

Dr. FLETCHER. Well, Senator Gore, it is hard to go into all of the details, but there are two principle reasons. One has already been discussed at some length. He is in some difficulty with the Gramm-Rudman or the Deficit Reduction Act, just as the Congress is, and he is trying to figure out where to get the money which you properly outlined. From what other budgets can it come from in order to support the space program?

That is one problem. The other is that he has a staff and they are not unanimous in wanting to go ahead with the program, at least right away, and they do not like to see the money taken out of some other part of the government. So he is faced with the same problem that the Congress is faced with, where does the money come from?

Senator GORE. Well, those are the kinds of problems that are normally solved by leadership. That is really what we are missing here. Long-term damage could be done to NASA. It is already being done.

And we have all expressed our frustrations here, and I am sure that you are frustrated where you sit as well. But the only crew that can solve this problem is down at the White House. They need to offer some leadership and they need to back up the President's eloquent speech with some substance.

We have had the rhetoric about how important NASA is to the country and about how we are not going to let this tragedy stop us in our effort to explore space. We have had the rhetoric. It was very moving. It was a very powerful speech.

We do not have the substance and we do not have the leadership.

Senator RIEGLE. Dr. Fletcher, just to conclude, I want to thank you for coming this morning and your associates who are with you. I want to make a personal observation, if I may.

I want to commend you and the others at NASA for the number of steps that have been taken recently to deal with the aftermath of the accident. I think the personnel changes, I think the other steps that deal with administrative issues and mechanical issues along the lines of the recommendations from the Rogers report—it seems to me that you are moving ahead and that you are moving ahead rapidly on a number of difficult issues.

And that has not gone unnoticed by me and I appreciate it. You said you would move in that fashion and you have done so. I think you should be acknowledged here for that work, and we appreciate it.

Dr. FLETCHER. Thank you.

Senator RIEGLE. I know these are not easy days. I know that just having these discussions here today is difficult and painful in many ways. I just want to say that I understand that and I appreciate that as well.

My final thought is this, and I wanted to express this to Senator Gorton, but he had to go to the floor. But I want to say this for his benefit through his staff and others here. I am going to suggest to Senator Gorton that I think the subcommittee needs to sit down together with the policy people in the Administration and have a frank, friendly, closed door discussion as to where we are here.

I do not think we can fly blindly on these issues. I think there has to be coordination that is at the moment missing. So I am going to suggest to Senator Gorton that he undertake to see if he could arrange for us to sit down with whoever we can so arrange to meet with in the executive branch, to see if we cannot between ourselves come to some meeting of the minds as to where we are.

I do not think it is sound for us to go ahead with the markup on our own when we still do not have policy recommendations and decisions from the White House. Perhaps we will have to do that anyway, and I am prepared to see us do that if all else fails.

But I think we ought to try to take an affirmative, cooperative step to at least see if we cannot have a conversation face to face ahead of time and see if we cannot perhaps arrive at some resolution to some of these problems that can help you do your job and enable us to be a bit better legislators.

So I will seek to do that. And depending upon our ability to do that, we will try—I will try, with my colleagues, to fashion an approach here, a budget approach that would seem to meet the critical needs that you are facing and that would face them fully so that we are not kidding ourselves about asking for less than is required to get key things done.

So I do hope to take those steps, and I wanted you to know that and I wanted everybody else to be on notice as well.

The subcommittee stands in recess.

[Whereupon, at 12:11 p.m., the subcommittee was recessed.]

ADDITIONAL ARTICLES, LETTERS, AND STATEMENTS

STATEMENT OF AEROSPACE INDUSTRIES ASSOCIATION OF AMERICA, INC.

The Aerospace Industries Association of America, Inc. (AIA), is the national trade association representing U.S. companies engaged in the research, development and manufacture of aerospace systems, including aircraft, missiles, spacecraft and space launch vehicles, and propulsion, guidance, control and accessory equipment for those flight vehicles. We appreciate the opportunity to present to the committee the views of the aerospace industry relative to the Fiscal Year 1987 budget for the National Aeronautics and Space Administration.

NASA's role as a technology generating agency has never been more important to the aerospace industry and to the nation's future, because our status as technological leader of the free world is being challenged as never before, most particularly in aeronautics and space. This challenge has serious implications for our nation's trade posture—hence our economic future—because aerospace is one of the few sectors of U.S. international trade that has consistently enjoyed a positive trade balance. In the 1980s, the nation as a whole has experienced huge international trade deficits, setting new records in each of the past five years. By contrast, the aerospace industry has recorded—over that same period—positive trade balances of more than $10 billion in each year for an aggregate of almost $60 billion. That performance, offsetting to a considerable degree the adverse impact of trade losses in other areas, clearly underlines the importance to the U.S. economy of high value, high technology aerospace exports.

Last year, the industry once again set a new record for aerospace exports—in excess of $18 billion. At the same time, however, aerospace imports also reached a new record of $6 billion. This is a relatively new phenomenon. As recently as the late 1970s, aerospace imports hovered around one billion dollars. Since that time, however, foreign producers have greatly increased their shipments to the U.S., both in the form of finished products and intermediate goods for use in U.S.-finished aerospace products. Such countries have recognized the importance of a healthy aerospace industry and have encouraged the growth of their domestic aerospace industries accordingly.

The only effective response we can make is to respond in kind, i.e., to meet the challenge by building on our traditional technological strength. AIA has published a study report—entitled Aerospace Technology of the 1990s—that outlines a plan for revitalizing American competitiveness through bold and innovative technology thrusts. The plan envisions an intensified research and systems technology effort focused on certain technologies that have real potential for significant improvements in the cost and performance of aerospace products for the 1990s, and hence offer the greatest payoffs in terms of U.S. trade, defense, space capacility and health of our overall economy. The report states that, along with greatly increased performance and reliability, it now appears possible, within that time frame, to achieve operating cost improvements of 30 to 50 percent for new aircraft and as much as a tenfold improvement in the effectiveness of space systems. Gains of such an order would, of course, dramatically enhance U.S. competitivenes, and lend significantly to the reestablishment of U.S. product superiority where it has eroded and expand it where it still exists.

Such goals are technically capable of achievement. NASA's research and technology effort is particularly important to that end. NASA's current work in subsonic aircraft technology is already advancing many of the high payoff technologies identified in the AIA report. Successful transfer of such technologies to the private sector will pave the way for a 1990s generation of superefficient and affordable civil and military subsonic airplanes, and will provide a big boost to the aerospace industry's ability to surmount foreign competitive challenges.

Looking slightly farther down the road, NASA also figures prominently in the two greatest aerospace challenges presently on the horizon: the National Aerospace Plane and the permanently-manned Space Station. The aerospace plane is a technology advancement program with exciting potential for the future of civil aviation and U.S. competitiveness in the international market. Similarly, the Space Station program serves as a focal point for the development of a number of technologies, in particular those related to commercial exploitation of the Earth orbital environment.

With regard to the NASA Fiscal Year 1987 budget proposal, we are aware that the tragic accident to Space Shuttle Flight 51-L will require restructuring of NASA's plans and inevitably influence budget allocations. This statement is necessarily based on the NASA budget proposal as submitted by the President before the loss of Challenger.

Generally, the aerospace industry supports the Administration's proposal with one reservation: we must caution, as we have in the past, against declining allocations for space science funding. Among the major categories in the budget summary, the only areas of reduction below the previous year's levels are in the space science programs. This is not to suggest that space science is being seriously neglected—as yet; but the proposal for negative growth in this important area strikes a warning note. Science and technology are inseparable; science is the wellspring of technology, the informational base for tomorrow's practical applications. If we are to maintain our world leadership in science and technology, we must not succumb to the temptation to subordinate the space science effort to the more publicly visible promise of harvesting practical benefit in space. For a balanced program, we must support both.

AIA also supports the provisions of the Administration's FY 1987 NASA budget proposal that will allow completion of the initial design and definition studies and initiation of Space Station hardware development in 1987. The Space Station is more than "the next logical step;" it is an absolutely essential step that would remove many of the constraints presently inhibiting our full realization of the promise of space.

The flexibility afforded by the Space Station offers a number of advantages for our space operations: continuous operations in space; an orbital facility for scientific experiment and direct-benefit Earth applications; a base for Orbital Transfer vehicles capable of delivering, servicing and retrieving orbiting payloads in geosynchronous orbit; a facility for assembly and checkout of future space systems; a staging point for erection of very large orbital structures; and, finally, a way station between Earth and distant space.

For these and other reasons, the Space Station is vital to the nation's competitiveness, its economy, its defense posture, and its relationships with other countries. Particularly during the present time of turmoil in our space program, we must be sure or hold to our vision and purpose in space. The recent report of the National Commission on Space points us clearly toward an exciting future. In whatever form that future takes shape—however different it may evolve in particulars from the picture the National Commission has described—we cannot afford to falter in our basic commitment. Others will not; not the Soviets, who push consistently to develop their space capabilities, not the other industrial nations, who see clearly the long-term potential for economic and social benefits of immense order.

The achievement of this potential will require a willingness of private companies to commit large scale technical and financial resources to high risk orbital ventures. A requisite for attracting such commercial investment is a firm national commitment to the development and timely completion of the Space Station, to assure prospective investors that permanent orbital research and manufacturing facilities will be available to them.

Turning to aeronautical R&D, the AIA Board of Governors has endorsed the goals propounded by the Office of Science and Technology Policy (OSTP) and has stated an aerospace industry commitment "to foster and support a bolder national research and development program, one focused on key technologies which can ensure that the U.S. maintains a position of aerospace product superiority in the world marketplace."

The subsonics goal set forth by OSTP parallels the plan for revitalized American competitiveness advanced in the earlier-mentioned AIA report *Aerospace Technology for the 1990s*. It envisions an entirely new generation of extraordinarily efficient aircraft, including commercial transports, military airlifters and high speed rotorcraft. Such aircraft would burn substantially less fuel than their current counterparts, have dramatically lower overall operating costs, be producible at lower cost - hence more affordable - and provide superior transportation at relatively low fares.

NASA has made considerable progress in the areas of technology considered essential to the development of such subsonic aircraft: propulsion systems, laminar flow control, structures and flight controls. AIA favors continuation of this effort and acceleration where necessary to permit transfer of such technologies to the private sector on a timely basis. Timely, in this instance, means being available for adaptation to new aircraft by the early 1990s, to meet the market demand and competitive challenge anticipated for that time frame.

The aerospace industry is generally supportive of the Adminstration's proposal to proceed with development of a prototype aerospace plane and is specifically supportive of the proposal for NASA initiation of a transatmospheric research and technology program that will consider the civil aviation applications of such technology.

The aerospace plane represents the first step toward the transatmospherics goal set forth by OSTP and endorsed by industry. The vehicle envisioned by OSTP is one that could take off and land horizontally on a standard runway, cruise in the atmosphere at hypersonic speeds, or fly into low Earth orbit. Successful demonstration of the requisite technologies by the proposed experimental flight vehicle would pave the way for three important applications:

A new class of military reconnaissance/intercetpor aircraft of extraordinary performance and survivability;

A space transportaion vehicle providing rapid access to space where required and delivery of payloads to orbit at costs dramatically lower than today's;

A hypersonic commercial transport.

From the standpoint of international trade competitiveness, the latter vehicle is a particularly exciting possibility. Many experts feel that the high speed airliner of the 21st Century will not be a premium fare transport restricted to a few routes. Expanding trade with the developing nations of the Pacific Rim, South America, Asia and Africa will involve air travel at greater stage lengths, which in turn will demand greater speed. If, as many experts feel is possible, advancing technology can curb operating costs—and fares—while significantly elevating transport speeds, the hypersonic airliner could become the dominant mode of long haul transportation in the 21st century. The nation that develops it could enjoy preeminence in the world transport market for a long time.

In AIA's view, the United States has a solid lead in key areas of transatmospheric technology and thus is better positioned than competing nations to take advantage of this opportunity for a technological revolution in aviation and space. But such advantage is temporary. Others are also investing in the relevant technologies, so it is important that we pursue the opportunity in timely fashion. In sum, the transatmospheric technology program offers greater potential benefit to defense and space capability, American trade competitiveness and the U.S. economy than any other program in being or on the horizon.

Statement of Robert E. Berry, Director, Space Systems Operation, Ford Aerospace & Communications Corp.

It is my privilege to submit this statement to the Senate Committee on Commerce, Science, and Transportation Subcommittee on Science, Technology and Space.

My comments have been requested concerning (a) the lack of funding for the Advanced Communications Technology Satellite (ACTS) program in the Administration's fiscal year 1987 budget, (b) the significant and potential uses of ACTS technologies, and (c) the extent to which the private sector could be expected to develop the same technologies.

A. ACTS AND THE 1987 BUDGET

I would like to begin by stating that my colleagues and I see great value in NASA's sponsorship of communication satellite technological advances, and we believe that this presents important advantages to the United States. I will discuss later why we believe these technologies will have positive impact on the productivity of U.S. business and industry, and therefore on the wellbeing of the overall U.S. economy. We do not, however, see ourselves in the position of having the perspective to relate the value of the ACTS program to all the other programs competing for federal resources in an era of legislated requirements for reduced Federal spending. We are also aware that this choice has not been made easier by the need to find resources to enable NASA to meet its mission responsibilities in the post-Challenger period.

B. SIGNIFICANCE AND POTENTIAL OF ACTS TECHNOLOGIES

We see the technologies associated with the ACTS program as the latest generation in the technical advances that began with SPUTNIK and earlier with the invention of the transistor. These have led to the communications satellite and to solid state electronics in miniaturized form which underly the pervasive computational capabilities that affect all of our lives in almost everything we do today.

Acts will truly be a state-of-the-art application of the latest in both space and electronics, with its microwave switching capability, its VHSIC electronic packaging applied to on-board baseband processing, its multibeam antenna and its optical intersatellite link. ACTS groups all of these into an integrated system for enhanced high quality, low cost telecommunications. ACTS does this in a manner which permits development of techniques to both build the satellites and ground equipment as well as to form the planning for their utilization. We believe the utilization of the ACTS as an integrated expression of this combination of technologies has a special significance. We believe that only with an ACTS satellite in orbit can the full development of the spectrum of application be planned, tested and measured as to economic benefit.

It is our belief that when those requirements are made and validated, ACTS will have established another dramatic reduction in the cost of telecommunications, which will inevitably result in the introduction of yet another series of new telecommunications services. We see these technologies and these services particularly applying to business telecommunications.

We have observed that technologically induced reductions in the cost of business telecommunications generally lead to new services which have the effect of improving the productivity or efficiency of the businesses which employ them. More timely information, available with greater accuracy or more relevance, is used to make faster and more accurate decisions at at all levels. Interconnection of computers and machines makes the processes of a business more efficient - whether in design, accounting, planning, purchasing, production or management. We expect the ACTS technologies, when applied, to result in significantly improved productivity gains across a wide range of American business and industry.

We also see the ACTS technologies, when applied, enhancing a broader geographic distribution of American business and industry. We see the business and industries now operating in rural areas getting a relatively greater benefit from the utilization of ACTS technologies because of the inherent interconnective character of these technologies. And, because of greater ease of rural operations, we see a relative growth in business and industry in rural America.

C. WILL THE PRIVATE SECTOR DEVELOP THE ACTS TECHNOLOGIES?

We believe it is inevitable that American business and industry will demand the technologies being developed in the ACTS program. American business will come to perceive that without these technologies their competitiveness in the World marketplace (which also means the U.S. marketplace) will be endangered. We believe the key issue, therefore, is when the ACTS technologies will be available to American business and industry and whether American business and industry will be able to lead the World in applying the resultant productivity gains, or whether American business and industry will be among the also rans in receiving ACTS technologies and in applying the resultant productivity gains. We think that any situation which has American business and industry falling behind in productivity improvement doesn't bode well for the American economy or the American worker.

We think that deregulation in telecommunications, however, has tended to remove from the private sector in the U.S. the overview perspective of the market totality of U.S. telecommunications services and demand. And we think the ACTS technologies are associated with an overall telecommunications perspective. We are therfore concerned whether the telecommunications private sector, now relatively fractionated, will respond repidly and vigorously to the system level opportunities which the ACTS technologies present. For these reasons we believe the U. S. development and introduction of the ACTS technologies will lag behind Japanese and European activities in this field unless an appropriate Government policy encourages timely U.S. private investment. We see the ACTS program as precisely the right instrument for that appropriate Government policy.

We hope that, after due consideration to all the other Federal priorities and to all the other NASA priorities, the benefits of the ACTS program are able to merit the continued investment of the Congress and the Administration. We believe that investment will build a more productive, more economically healthy America in the years to come.